SD11
A5A3
1949

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

FOREST SERVICE
SOUTHWESTERN FOREST & RANGE EXP. STA.
TUCSON, ARIZONA
APR 19 1950
RECEIVED

ANNUAL REPORT

1949

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION

Berkeley, California

Stephen N. Wyckoff, Director

Routed 4-19-50
Ret'd. 7-17-50

Not for publication

In cooperation with the University of California

M—5123

U. S. GOVERNMENT PRINTING OFFICE

8—7417

Contents

	Page
Foreword	i
Forest Management Research	1
Forest Genetics	10
Forest Fire Research	14
Forest Economics	19
Forest Utilization Service	30
Range Research	35
Forest Influences	46
Flood Control Surveys	59
Staff Publications, 1949	64

R-CAL
REPORTS
Station's Annual

April 1950

ANNUAL REPORT OF THE

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION[1/]

1949

FOREWORD

The foreword to the annual report of this Station for 1948 drew attention to the rapid increase in the population of California and the resulting demands upon the renewable wild land resources of the State. This has continued in 1949 and will doubtless be of paramount importance for several years to come.

The population of the State in 1946 was approximately 9½ million. Present estimates indicate that the 1950 census will show 11½ million. The present distribution of these additional 2 million people is not yet accurately known. Many have come to the metropolitan centers and to the agricultural areas. But merely to travel through the mountainous portions of the State shows that large numbers have settled there, in or near the smaller towns, and to a constantly increasing degree scattered through areas previously used only for timber or forage production. The amount of land removed from production is probably negligible; the important fact is that many such areas are assuming a character which can be termed almost suburban. This, and the increasing demands for forest recreation and for greater production of timber, forage and water are having and will continue to have definite effects on wild land management. Three examples will illustrate some of the resultant problems whose solution depends upon more adequate research information.

Timber Production and Reserves

Lessening timber reserves in other regions coupled with increasing local demands have increased lumber production in California to the highest point in its history. During the half decade of 1944-1948, production increased from 2½ billion to 4 billion board feet. Estimates now being assembled indicate a decrease of some 300 million board feet in 1949, probably a general reaction to market conditions rather than a local trend. In 1948 California ranked second to Oregon in lumber production. Humboldt County in the redwood region of the State assumed second place in production by counties, being exceeded only by Lane County, Oregon.

By species, the heaviest production has been in ponderosa pine, Douglas-fir, and redwood, in decreasing order of volume. Douglas-fir production, in third place in 1944, had risen to second place in 1948.

1/ Maintained by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California at Berkeley, California.

Such demands, met primarily from the old-growth timber resource, point up sharply the need for development and application of more intensive methods of forest management, to convert old-growth stands to managed, growing forests, and to get regeneration on forest lands of good site quality now deforested or nearly so. The case of the large old-growth stands of Douglas-fir is an excellent example of this need, but is by no means the only one.

Contrary to general opinion, the commercial forests of California contain more mechantable Douglas-fir than any other species, with ponderosa pine second and redwood third. The Douglas-fir occurs in a variety of stands and in widely differing localities. It is a frequent associate of redwood in the northwestern part of the State, and there attains its best development. Many of the mixed-conifer stands of the west slope of the Sierra Nevada contain appreciable amounts of Douglas fir. The greatest volume of the species is found in the inner, eastern portions of the northern Coast Range, beyond the coastal conditions which favor redwood and where, in some sites the fir is associated with ponderosa pine. This total area, of about 5 million acres, contains almost 60 billion board feet of Douglas-fir.

Much of the Douglas-fir is old, large, and contains much decay. The conversion of these stands to managed, growing forests is a difficult and challenging problem. Its solution demands re-examination of the orthodox concepts of silviculture and of current methods of management. Wisely handled, however, the Douglas-fir stands can become a permanent forest area of great productivity, contributing materially to the annual lumber production of the State.

Brushland Improvement

One of the most controversial questions now facing the region is that of the feasibility and advisability of converting brushlands to range lands by removal of the brush cover. The State contains about 12 million acres of land called brushland, although an exact acreage figure could only be given with a precise definition of the term and more detailed knowledge of conditions on the ground. The controversy involves several points: The area from which brush could be removed completely or so thinned out as to increase grazing capacity materially, the economic feasibility of such undertakings, and the effect of such practices upon soil stability and water yield. The problem is complex, involving such variables as soil types, degrees of slope, amounts and intensities of rainfall, present types and densities of brush cover, and relative evaporative losses from soils bearing various types of vegetative cover. It has been well characterized as a thousand problems rather than one. A paucity of definite information has favored an undue degree of generalization in a subject in which precision of knowledge and limitation of consideration to small, homogeneous land areas are necessary for sound progress.

It can be accepted as a sound working hypothesis that there are areas of brushy cover from which the brush can be removed in whole or in part without deterioration of soil stability and water yield, and at

a cost that will return, through increased livestock production, a reasonable financial yield upon the necessary investment. The problem then is to determine the combined conditions of soil, slope, brush cover, and precipitation, the methods of brush eradication and kinds of forage cover which will bring the desired results. This will only be done by study of each variable factor and detailed knowledge of conditions, locality by locality, to indicate where the possibility of success exists.

The nature of this problem is such that it impinges upon the work of several Divisions of the Station. The divisions of Range Research, Fire Research, and Forest Influences Research would necessarily contribute to a well-rounded program of research in this field. Range Research will need to study the forage aspects; Fire Research, the behavior of fire on the lands in question, with particular reference to methods for and effects of controlled burning; and Forest Influences Research, the effect of proposed practices upon soil stability and water yield. The Forest Survey, particularly the kind of survey being conducted in cooperation with the State Division of Forestry, will determine the extent and location of vegetative types and other ground conditions upon which application of research results can be based.

In 1949 the Station was given facilities to work upon this problem for the first time, through an allocation of Research and Marketing Act funds for a study of brushland improvement. The amount of the allotment was such as to limit the work to only one of its several phases, and studies were instituted in certain of the forage aspects, under the supervision of the Division of Range Research. It is fully recognized that this is but a partial attack on the problem. At the earliest opportunity the work will be expanded into the other fields, and will involve the divisions of Fire Research and Forest Influences, as well as Range Research, to a greater degree than is now possible.

Water Yield and Conservation

A series of years with subnormal precipitation, particularly in the southern half of the State, has worsened the difficult situation arising from increasing needs for water. Depletion of ground water reserves is continuing in many localities. In the public mind the solution of the difficulty is either to build more dams to impound runoff, or to import more water from other regions, or both. The effect of land management practices on water yield and on soil stability as related to the life of storage structures is but little realized and understood.

Thus there is great need for a materially expanded program of research upon the influence of vegetative cover upon water yield and soil stability under the particular series of conditions existing within the region. Such a program would be most advantageously conducted by a number of agencies and institutions, with full provision for interchange of information and joint analysis of environmental conditions and experimental techniques when results are at variance. And it should inquire critically into all past, present, and proposed management practices on agricultural, forest, range, and barren lands of watershed significance.

Station Staff Activities

During 1949 there have been relatively few changes in the staff of the Station, and the number of persons on the staff has remained about the same. The Station continues to benefit from its move, in 1948, to the Forestry Building on the campus of the University of California. For the first time in a number of years almost all of the staff headquartered in Berkeley are under one roof, with attendant simplifications in operation and an increased feeling of Station unity.

One of the great advantages in the Station's location on the campus of the University, and in close contact with the faculty, was made apparent by a recent check on the formal educational work of the staff. During the three college years 1947-48, 1948-49, and 1949-50, 11 members of the Station staff have enrolled in 63 courses offered by the University, representing a total of 169 units of credits. Nine men are definitely working for higher degrees. This does not include a number of persons who have audited courses without enrollment for credit, at the University or elsewhere, nor courses taken for higher degrees at other schools. Practically all of the courses taken have pertained directly to the background of the official work of the individuals concerned. This opportunity for educational advancement of the staff and for informal conference with Faculty members on various phases of the official work combines with the active cooperation under way between the Station and the University to make the relationship a most fruitful one.

FOREST MANAGEMENT RESEARCH

(Duncan Dunning, Chief of Division)

Objectives for 1949

1. Ponderosa Pine Management

a. Complete the reinventory of the Blacks Mountain Experimental Forest so that a 12-year progress report can be made.

b. Continue analysis of growth and stand structure change for the above progress report.

2. Mixed-conifer Management

a. Complete conversion cutting tests in sugar pine--fir at Stanislaus, logging about 4 MM b.m. on 108 acres.

b. Examine the 1948 Stanislaus cutting areas for results of natural reproduction, seeding, and rodent control. Remove 256 M b.m. of seed trees from 1948 area.

3. Mensuration

a. Publish form-class volume tables, if funds available.

b. Continue analysis of mixed stand growth data for publication.

4. Regeneration

a. Transplant hybrid nursery stock. Prepare test fields for outplanting, if possible.

b. Transplant and outplant present nursery stock for grading tests and reexamine established plantations at Feather River.

c. Complete germination tests for cone ripening study.

d. Continue analysis of reproduction, seed crop and site-factor records for publication.

e. Continue cooperation with University of California in rodent-tree-regeneration studies.

5. Continue supplying materials and advice to practicing foresters on pine and mixed-conifer management.

Activities and Accomplishments

Some deviations and changes in emphasis from the plan made in 1948 were necessary or desirable. Mensuration work was delayed by an incapacitating injury suffered by the section leader, V. A. Clements. Four younger members of the division took advantage of opportunities for advanced study--including European travel for one. Also, a gratifying interest in the results of research developed during the year, presenting the opportunity for increased emphasis on applying the results in forest management; this required more attention from older members of the Division than was anticipated.

Ponderosa Pine Management

Reinventory.--The reinventory of Blacks Mountain Experimental Forest was completed to revise the working plan, to show changes since 1934, to test the feasibility of using stand condition-classes in surveys for working plans, and to provide material for a general progress report. Of the 100 compartments, 29 were chosen at random for survey. Condition-class areas were sampled by line intercepts and stand structure by plots along 5,502 chains of cruise strips. Methods-of-cutting plots that had run 5 and 10 years were remeasured for growth. The survey and plot measurements were made at the end of the field season when men became available through completion of logging in the sugar pine type.

Logging equipment was transferred from the Stanislaus to the Blacks Mountain forest in December and is being reconditioned with a view to cutting about 4½ million feet in new experiments in 1950. Appraisal for the new sale was completed.

Analysis of Records.--Compilation of growth and stand-structure records was begun in December. Most urgently needed is information for revising the working plan, especially the allowable cut before logging is resumed in the spring. Analysis progressed far enough to enable preparation for the 1950 sale which will be advertised in April. Much more remains to be done before the general progress report can be written.

Other Activities.--Natural regeneration was recorded on 9 sample areas following the heavy ponderosa pine seed crop of 1948 on land cut-over in 1947. Some of the sample areas were scarified accompanied by rodent poisoning, the remainder being untreated. The following summary, based on 504 milacre quadrats, shows seedling incidence and survival at the end of the 1949 season:

Condition of surface	Incidence, seedlings per acre	Survival, percent
Bare soil--untreated	1,504	24
Bare soil--scarified, poisoned	33,329	42
Light vegetation--scarified, poisoned	11,420	26
Medium vegetation--scarified, poisoned	3,816	19
Heavy vegetation--scarified, poisoned	2,914	16

These early results indicate that rodent control was fairly successful; that competition from the vegetation--mainly perennial grasses--was not completely eliminated by use of the Towner disc, and seriously reduced germination and survival; and that except where vegetation was heavy enough seedlings may be established for moderate to good stocking.

Remeasurement of 25 groups of pruned crop trees indicated that diameter growth was not reduced by removal of one-fourth of the green crown; but removal of half the crown reduced growth to 64 percent of the rate for controls; and pruning three-fourths the crown, to 8 percent. Insects attacked 72 percent of the trees with three-fourths of the crowns removed and killed 36 percent. Little damage was suffered by the more lightly pruned trees.

Mixed-conifer Management

Conversion Cutting.--Cutting in old-growth sugar pine at the Stanislaus Experimental Forest removed 4.4 million board feet from 110 acres.

Cutting followed the condition-class pattern, as in 1948, but certain changes were made because no sugar pine seed ripened in 1949. On unit-areas where sugar pine regeneration was the object, treatments were frankly designed to favor complete planting rather than natural seeding. No large seed trees unsuitable for reserves were left temporarily as special seed trees, as was done in 1948. Slash disposal and ground preparation in the clear-cut groups were done with a view to reducing the cost and increasing the success of planting.

The commitment to planting admitted greater freedom in marking, logging, and slash disposal: Regeneration clearings were less restricted in size and shape, logging did not have to be planned to enable returning for temporary seed trees, and slash disposal equipment could be used freely to promote burning later in the season without regard to seed fall.

Only 24 percent of the 1949 cutting area was rated suitable for immediate regeneration of sugar pine; the remaining 76 percent was cut for advance-growth release, or for regeneration and improvement of fir and minor species. Sugar pine regeneration cutting for the two years, 1948 and 1949, covered 29 percent of the area.

For the 201 acres cut-over in both years, the original stand averaged 79 M bd. ft. to the acre; 46 M was cut and 33 M was left as averages for the area as a whole. The cut from regeneration clearings alone averaged 88 M. This heavy localized cutting resulted in considerable concentration of slash.

Slash disposal, as in 1948, was restricted to the regeneration clearings and was accomplished by late burning after bunching--mostly with RD-7 tractor and dozer. A smaller, D-4 tractor and blade with special slash piling teeth was tested, but was abandoned because it tipped on slopes and was unable to tear out tough green shrubs. The cost of slash disposal in 1949 was $0.23 per M bd. ft. of total cut, or $38.81 per acre actually cleared for regeneration. The cost was $5.75 less per acre than in 1948, mainly because clean-up can be less thorough where planting is planned.

Attempting to reduce logging damage, considerable experimenting was done with an auxiliary tractor, breaking out logs to a larger tractor with arch by ground skidding and by use of a line pulled out by hand. This resulted in much less damage than using the arch throughout. The gain was made at very little extra cost for yarding in the special circumstances: ground skidding was used on steep slopes and in heavy reserved stands where use of the arch was either impractical or more costly than ground skidding; also, the auxiliary tractor increased log out-put, partially offsetting extra costs of its use. It is not possible to determine just what proportion of costs were chargeable to preventing damage, but it is safe to say that the total was insignificant in comparison with the cost of replacing well-established young growth that might have been destroyed.

Erosion control in conjunction with logging is of considerable interest on the important Stanislaus watershed. The productive top-soil is relatively thin and its loss is a matter for concern in silviculture. Measures taken consisted in blocking skid trails at frequent intervals to divert water into stabilized natural channels or onto ground with undisturbed cover, and reopening natural channels where crossings were unavoidable. Such work was done with tractor and dozer by an operator experienced in logging and road drainage control. Advance planning for log transport minimized drainage crossings and correction measures. These simple erosion control operations cost 1½ cents per thousand feet of timber cut. How effective the work will be is not yet apparent. The Division of Flood Control Survey established several reference stations with the object of preliminary estimates of soil loss after the first seasonal run-off.

Results of 1948 Cutting.--Natural reproduction of sugar pine resulting from the 1948 cutting was somewhat disappointing although moderately successful. The heavy seed crop and seed-tree arrangement resulted in unusually good seed distribution--29,000 good seeds to the acre. Seedling sugar pines appeared at the rate of 707 to the acre of regeneration cutting, with about 35 percent of the milacre quadrats stocked. By the end of the 1949 season the number of sugar pines was reduced to 440 to the acre, with 25 percent of the quadrats remaining stocked.

White fir seed fell on the same areas at the rate of 161,000 good seeds to the acre. By the end of the season 53 percent of the milacres had one or more fir seedlings.

There were no tree seedlings at the end of the season on 41 percent of the quadrats.

Small rodents doubtless were the principal cause of reduced germination, despite the hopes expressed in 1948 for success of poisoning. Apparently reduced to low populations in the fall of 1948, rodents were again abundant in the spring of 1949. Their depredations were widely apparent. Sugar pine seedlings were present on 41 percent of the seed spots protected by screens, whereas but 18 percent of unscreened spots produced seedlings. The difference would have been greater had not the rodents entered some of the screens.

Failure of seeds to become covered with soil no doubt contributed to reduced germination. This was indicated by trials of raking the soil after natural seed fall. Sugar pines germinated on raked soil at the rate of 2975 to the acre, as against 1550 on unraked plots.

Although reproduction stocking is several times as good as that resulting from previous cuttings, it is deficient by standards of good management set for the experiment. In consequence a somewhat larger proportion of the area will have to be planted than was planned. Shrub seedlings--Ceanothus, manzanita and Ribes--appeared in moderate numbers in the first season after logging--an obvious warning that planting should be completed in the spring of 1950. Because conditions were unfavorable in the fall of 1948, only 12 acres were planted.

Mensuration

Volume Tables.--Form-class volume tables for five of the important interior species were published in two series--the first, for ponderosa pine, Douglas-fir, and white fir; the second, for sugar pine and red fir. A large number of copies of these tables was distributed, and requests for them continue.

Instruction in special routines necessary for using the tables was given technicians of the State Division of Forestry during a group training session in the field.

Considerable progress was made toward developing an instrument for measuring form-class before the work was discontinued.

Growth Analysis.--Analysis of mixed-stand growth data also was delayed by injury of Clements and by educational furlough for C. W. Stevens.

Some 41 items of stand structure and other material were assembled in temporary form as a handbook for field men and use in training sessions. Several items from the list were incorporated in a pine region forest handbook published by the State Division of Forestry.

Regeneration

Hybrid Planting.--Hybrid pine seedling stock in three experimental nurseries was transplanted and is ready for outplanting in the spring of 1950. Considerable damage to the Stanislaus transplants was caused by soil-inhabiting insect larvae that survived all measures of control. Enough transplants will be available for field testing unless additional losses are caused by winter agencies.

Three areas were cleared of brush and trees for field tests of hybrids and other planting stock. Two of the areas are in the Stanislaus Experimental Forest and represent high-quality pine sites of north and south exposures. The third, in the Feather River Experimental Forest, is a flat in mixed conifers of medium site.

Seed-grade and Stock-grade Planting Tests.--A comparison of planting stock resulting from three sizes of seed, seedlings, and transplants was begun at Feather River with sowing the seed in 1938. The primary object was to develop more successful ponderosa and Jeffrey pine planting stock, but a secondary objective was to discover criteria for early identification of crop-tree dominants. The trees were planted closely spaced--3 feet x 3 feet--to insure early stand closure. Survival averaged about 90 percent in 1949 and tree height ranged from less than 1 foot to about 9 feet.

There were no important differences in proportion of dominants, average height, or survival between trees originating from small, medium, and large seed.

About 82 percent of the dominants came from transplants of the medium and large grades; 80 percent of the dominants started as medium and large seedlings.

There were small but significant differences in survival and height growth between the grades of both transplants and seedlings, the smaller trees being consistently inferior.

Reduction in mortality and increase in average height could have been accomplished by discarding either small seedlings or small transplants. Such culling, as previously indicated, would have sacrificed trees that included 18 to 20 percent of the potential dominants.

Size alone clearly is not an extremely critical grading criterion, but use of size standards would be consistently in the direction of improvement. It is to be expected that greater success in planting will be attained through the cumulative force of many such improvements rather than through some marvelous discovery. That one-fifth of the dominants came from small grades points to seed source as a profitable field for additional gains.

Two tests of grading stock by both diameter and height have shown that trees of low diameter, even though acceptable as to height, are inferior as measured by first-year survival. A third study was begun in the fall of 1949.

Treatment of stock with a patented transpiration retardant (Ceremul c) did not increase survival.

Cone Ripening Study.--The germination rate for seeds from sugar pine cones collected in successive weeks showed a strong, consistent relation to specific gravity of the cones. As specific gravity declined from 0.92 in early September to 0.78 in October, seed germination percentage rose from 23 to 88. A method of cone sampling and testing to insure 80 percent seed germination was recommended in a Station Release.

Analysis of Records.--Reproduction occurrence during 20 years after logging in mixed-conifer types of the Stanislaus region was summarized in a manuscript being edited for publication. Further progress was made in the analysis of seed-crop and site-factor records for a general report on natural regeneration.

Rodents in Relation to Reforestation.--The cooperative study with the University of California continued with Dr. William Jameson making good progress at the Feather River field station, principally on the feeding and other behavior of several species of mice.

The Division's aim for improving the application of silviculture in forest management has been to make good and bad forestry more visibly distinct. The first step has been to formulate standards based on research; the second, to test the standards; and the third, to get influential foresters to examine, improve, and approve such standards. The third step has been taken in the woods, whenever possible, because in the forest words and things are more quickly associated in clear concepts.

This involved dusting off old materials long available, but unused, as well as reducing to prescription form recent results: Definition of crop trees--of seed trees--of stocking by site, age, trees, dominants, spacing, and yields. This material was processed and distributed to practicing foresters for trial and comment.

Several opportunities to contact practicing foresters in the woods resulted from the courtesy of P. R. Kevin, Division of State and Private Forestry. Valuable insight into problems was gained through field visits with project foresters of the Soper-Wheeler, Diamond Match, Shasta Forests, and Weyerhaeuser Companies.

Three members of the Division visited cutting and planting operations in Oregon and Washington to gain from foresters there new ideas applicable in California.

A brief course of field instruction was given 20 technicians of the State Division of Forestry in the application of condition-classes to working-plan surveys and stand-conversion treatments. A booklet of tables, graphs and other guides was prepared for this course. The forest management sessions were part of a general course at a State training camp in Amador County organized by State Forester DeWitt Nelson with cooperation of the Division of State and Private Forestry and the University of California School of Forestry.

Assistance was given the University of California field training school in selecting and classifying an area to be used for training students to recognize condition-classes in mixed stands.

A summary of the status of planting in California was made for consideration at a meeting of the State Board of Forestry. The planting survey report made in 1948 was reviewed in a field discussion by Forest Service Timber Management men.

The Office of Blister Rust Control continued active efforts to incorporate in control practices any information related to sugar pine management. Keys to crop-tree identification, reproduction stocking standards, and inventory methods were discussed in several sessions in the office and in field trials.

Soil Conservation Service representatives, T. B. Plair and Ray L. Kent, went over long-established second-growth experiments. They urged development of Challenge Experimental Forest in demonstration of the possibilities for improved small woodland management.

The sugar pine old-growth conversion cutting experiments in Stanislaus Experimental Forest attracted numerous visitors. Valuable suggestions for improving the studies were made by many experienced practicing and research foresters. Group visits to the area were made by the Forest Practices Committee of the Western Pine Association and by timber resource managers of the Forest Service.

At the request of the Conservation Committee of the Sierra Club a brief report was made regarding the status of replacement of sugar pine by white fir in the Calaveras area under consideration for a State park. This required a refresher visit to the South Calaveras grove of big trees for notes on stand structure, age classes, and stage of succession.

Increasing development of forestry in the redwood and Coast Range mixed conifers led to review of material on hand preparatory to expected field conferences on silviculture appropriate to those areas. Resumption of active research in the two regions is urgently necessary.

Plans for 1950

1. Ponderosa Pine Management

a. Resume experimental cutting at Blacks Mountain Experimental Forest, logging about 4½ million board feet.

b. Continue survival records of natural regeneration from the 1948 seed crop.

c. Continue loss records in cooperation with Forest Insect Investigations.

d. Remeasure methods-of-cutting plots for 5- and 10-year changes.

e. Publish progress report on crop-tree pruning.

f. Complete revision of Blacks Mountain working plan and prepare 10-year progress report.

2. Mixed-conifer Management

a. Continue survival records for sugar pine natural regeneration from 1948 and 1949 experimental cutting.

b. Finish supplementary planting on the sugar pine cuttings.

c. Prune test trees of sugar pine, white fir, and incense cedar.

d. Prepare condition-class standards for working plans and marking rules for mixed-conifers, including Douglas-fir.

e. Assist national forest supervisors to install trials of condition-class control on active timber sale areas, including redwood and Douglas-fir.

f. Publish progress report on sugar pine condition-class cutting experiments.

g. Publish report on incidence of natural regeneration for 20-year period after logging.

h. Issue a research note on rodent control costs in relation to pine regeneration cutting experiments.

i. Prepare a research note on slash disposal in connection with condition-class cutting in sugar pine.

j. Assist the Extension Forester and Division of State and Private Forestry in conducting a field training course in condition-class application for practicing industrial foresters.

3. Mensuration

Resume analysis of mixed-conifer growth and yield records.

4. Regeneration

a. Plant for additional field tests of stock grading criteria.

b. Plant hybrid pines in field tests at Stanislaus and Feather River Experiment Stations.

c. Begin study of the physiological condition of planting stock in cooperation with the University of California.

d. Continue cooperation with University of California in study of rodents in relation to forest regeneration.

e. Prepare manuscript on 10-year results of seed-grade and stock-grade tests at Feather River.

f. Assist Region 5 in formulating planting-stock grades.

FOREST GENETICS

(W. P. Stockwell, Chief of Division)

Objectives for 1949

1. Plant in the nursery, seed from 1948 collections and those seed of 1947 collections held over because of lack of water for nursery production.

2. Concentrate experimental crossing work on the southern pines.

3. Continue phylogenetic crossings as time permits.

4. Attempt production of test seed of the Coulter-Jeffrey hybrid--the goal being enough seed to produce 100,000 trees of this cross if funds for labor and material become available.

5. Complete old projects and undertake new work as indicated by results and available funds.

Activities and Accomplishments

Nursery Tests of Hybrids

The water supply was adequate in 1949, and the nursery planting was carried out as planned. Included were seeds of 14 white pine hybrids and 20 yellow pine hybrids. Most of these represented previous crosses, that is, the seeds were from pollinations which had been repeated as a check on previous results. Besides showing whether the cross took and produced good seed, the nursery plantings are used to study the general characteristics, vigor, and adaptability of the new trees and to provide a few seedlings for permanent plantations and test plots.

Seedlings in the 1949 planting demonstrated that several interesting crosses had been successful. The Asiatic white pines showed unexpected affinities with American pines. Seedlings were produced from Pinus parviflora crossed with our western white pine and from two Asiatic white pines--P. Koriaensis and P. Armandi--crossed with sugar pine, the first crosses to yield seed on sugar pine. Seeds of this sugar pine cross had previously failed to germinate, but Dr. E. C. Stone, now with the University of California, produced the seedlings by his embryo culture method. The Himalayan white pine, P. excelsa (Griffithi) crossed successfully with limber pine, P. flexilis.

Seedlings among the yellow pine crosses include several having one Southwest parent. The hybrid between Jeffrey and ponderosa pines was crossed with Apache pine. Both the Apache pine and the Arizona pine were crossed with pure ponderosa.

Perhaps the most interesting of all the yellow pine crosses, however, is that between Digger pine and Torrey pine. Both are fast growing and drought resistant, but the Digger pine is notorious for its poor form. If this is overcome by the Torrey pine growth habit, the hybrid may be of considerable value in dry, hot situations.

Southern Pine Crossings

Because cone production was light in 1949 work with the southern pines was limited to crosses of P. echinata with P. caribaea and with P. palustris. Pollen for this work was supplied by the Southern Forest and Range Experiment Station. The yield will be small but it is hoped a few hundred seeds of each cross will result.

Phylogeny

The phylogenetic crossing program was limited to 53 pollination bags. Three seed trees were chosen for testing: (1) P. muricata was pollinated with pollen of P. radiata, P. attenuradiata and P. attenuata; (2) P. sylvestris was pollinated by P. Banksiana, P. Murrayana x Banksiana, and P. Murrayana; (3) P. attenuata was pollinated by P. radiata, P. attenuradiata and P. muricata.

Mass Production of Seeds

The R-5 Timber Management division financed the travel and incidental costs necessary for production of hybrid seeds desired for field trial by the region. Unfortunately, in 1949 few conelets were borne on ponderosa and Jeffrey pines in the El Dorado transect. Because of the light cone crop, only 582 bags could be placed on Jeffrey pine for producing the Jeffrey x Coulter hybrid that is resistant to the pine reproduction weevil. Instead of seed for 100,000 trees we will be fortunate to get one-third of that number.

Old Projects and Other Activities

Seed Distribution.--During the year many small lots of seeds were sent to cooperators for trial. These included about 1,000 hybrid seeds, 10,000 seeds of various exotic species, and 10 pounds from local species.

Elevational Strains.--Twelve-year height measurements were made in the transect study of elevational strains of ponderosa pine, and the draft for a report was completed. These transect studies have shown that trees grown from low-elevation seed are fast-growing, those from high-elevation seed, slow-growing and the character for fastness or slowness of growth is in part hereditary.

The high-elevation strains, when transplanted to low elevations, do not approach the height growth of low-elevation strains. A practical conclusion from this finding is that it is not wise to collect seed at high elevations for use in reforestation projects at low elevations. Furthermore, as strains from as low as 600 feet have survived at 6,000 feet without frost damage, it would seem desirable to determine the altitudinal range of low-elevation strains, to test how far these fast-growing strains can be safely moved uphill.

Biochemistry.--Biochemical work was confined to oleoresin studies. Analyses were completed for turpentine of P. echinata and P. rigida, supplied by the Southeastern Forest Experiment Station. Other analyses were made of geographic races of ponderosa pine.

Results of analysis of P. echinata are not in accordance with the data previously reported by Herty, inasmuch as no limonene was found in this turpentine. P. rigida turpentine is so different from the turpentine of P. rigida var. seretina that biochemically these two pines should be considered as two distinct entities.

The ponderosa pine analyses indicate a complex pattern of relationship for this species. Turpentine samples obtained from individual trees on the west slope of the Sierra Nevada are homogeneous in physical characteristics--all are laevo-rotatory. Samples from the east slope of the range and from southwestern Utah (Bryce Canyon region) are heterogeneous--some are laevo-rotatory, others dextra-rotatory. Turpentines from both the west-side Sierra Nevada and the interior trees contain carene; the west-side form contains cadinene; and the southwest Utah variety contains longifolene.

Races of Pine.--Field study of races of P. muricata throughout its range was completed by Duffield, and progress was made on a similar study of the races of P. attenuata. This work is related to the program of phylogenetic crossings in the closed-cone pines. Reports have not yet been made.

Variability of Rooting.--Rooting studies were continued with particular attention to the variability of rooting capacity between individuals, species, and hybrids. The white pines are, in general, hard to root from cuttings, yet cuttings of some individuals of P. strobus were more than 90 percent successful in striking root. Also, the hybrid between P. monticola and P. excelsa rooted rather freely. Other hybrids that produced free-rooting individuals were:

P. echinata x P. taeda
P. Murrayana x P. Banksiana
P. ponderosa x P. scopulorum
P. ponderosa x P. apacheca

This study now gives hope that practical production of hybrids from cuttings may become possible. The tests are of interest not only in the development of clones for many phases of genetics work, but perhaps even in the production of planting stock from cuttings.

Blister Rust Tests.--Tests reported by Dr. Willis Wagener, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, indicate that the hybrid between Himalayan and eastern white pine may be resistant to white pine blister rust. Twelve trees under test for 4 years at Rhododendron, Oregon, have suffered no damage from the rust.

Miscellaneous Tasks.--Some badly needed arboretum pruning and maintenance was done, as was the annual task of cleaning, repairing, and sterilizing bags and equipment.

Plans for 1950

Available funds will not permit field pollination or mass production of hybrid seeds in 1950. Other work of a more technical nature will replace these usual activities.

1. Tests of the effectiveness of pollination equipment and techniques will be conducted in conjunction with trial crossings of ponderosa pine with southwestern and Mexican pines available.

2. Crossings will be made of exotic species available in the Eddy Arboretum. This work will include production of as many seeds of *P. strobus* x *P. excelsa* as the arboretum material permits. This hybrid has demonstrated some resistance to white pine blister rust.

3. Studies will be started with the objective of finding causes for genetic incompatability among the pines. This program will require several years because only a limited amount of work can be done each season.

4. As opportunity permits old projects will be completed and other needed work will be undertaken. This will include taking advantage of any opportunities to continue or increase white pine hybridizing for blister rust resistance.

FOREST FIRE RESEARCH

(C. C. Buck, Chief of Division)

Objectives for 1949

1. Fire Damage Appraisal

Adapt the principles developed in the southern California study for use in appraising fire damage from increased runoff and erosion on all the remaining California national forests. Current work to be confined to development of methods.

2. Chemical Control of Vegetation

Maintain contact with work done by other agencies that has application to forest vegetation control problems. Promote pilot testing of new developments in this field, conducting such small-scale field tests of promising chemicals as opportunity permits. Complete manuscript on present recommended practices for control of forest vegetation.

3. Water and Chemicals for Fire Suppression

Continue the present study of wetting agents for fire suppression in cooperation with Arcadia Fire Control Equipment Development Center. The current specific objectives were to determine the desirable specifications for an effective wetting agent for purposes of forest fire control and define its specific uses for effective and economical fire fighting practice.

4. Fire Danger Rating

Analyze past fire danger records in relation to fire business on the individual national forests to do two things: more firmly establish the relationship between fire danger trends and fire business on individual forests and provide information necessary for further development of operational tactics aimed at more efficient protection under fluctuating levels of fire danger.

5. Large-fire Organization Management

Reanalyze large fire organization management practices to establish sound principles of organization control, use of technical staff, functionalization of organization elements and like problems.

Activities and Accomplishments

Fire Damage Appraisal

Early in 1949 conferences were held on each of the four southern California national forests to acquaint local personnel with details of intended application of the fire damage study results. This led to a complete recheck of protection personnel and equipment distribution well before the fire season. It also resulted in several modification of fire

fighting strategy during the year. The changes were aimed at securing an economic balance between potential damages and fire suppression costs--i.e., low value areas were sacrificed to save fire fighting costs, and on high value areas strategy was planned to hold burned area to a minimum.

Manuscripts were started during the year describing the hydrologic methods used in the southern California study and a general description of the overall job.

The northern California watershed fire damage study was started in mid-year and carried forward according to plan. Accomplishments included gathering precipitation data on northern California watersheds, stream discharge data, extensive field survey of the area under study, and selection of a number of burned areas for detailed study. Sufficient precipitation and stream discharge data are available to make possible extensive watershed hydrologic analyses; no significant amounts of erosion data are available. From the field studies we have been learning how to evaluate runoff and erosion potentials from evidence that can be observed on the ground. This must be the primary source of erosion estimates.

Northern California watersheds are used for timber and forage production and for recreation as well as for water alone. This leads to a much more complex problem of evaluating watershed damages due to fire than that encountered in the southern California study. For example, salvage logging and grazing on fresh burns so aggravate the effects of a fire that proper assignment of fire damages is extremely difficult.

Because of these complications and others associated with them, the method now under development will differ in many respects from that employed in southern California. One or more additional years will be required to complete preliminary phases of the job.

Chemical Control of Vegetation

Field work in the use of chemicals for control of vegetation consisted of putting out 25 pilot tests on the Shasta National Forest, using both 2,4-D and 2,4,5-T. This was done to guide the treatment of roadside strips previously cleared with a new type of brush mower. Other work consisted of reviewing all reports of current work available to us, attending meetings with representatives of other groups and agencies concerned with use of chemicals, and analyzing and evaluating the information thus gained.

Interest is widespread in the possible use of 2,4-D and 2,4,5-T for killing unwanted trees and shrubs on forest and range lands. Many individuals and agencies made field tests of these chemicals in the past year. Attempts to demonstrate their potential usefulness in terms of economic application have led, however, to the realization that trial and error methods are not giving practical answers. From reports of others and our own work it is evident that the problem is not to learn whether these chemicals will kill individual species of plants. It is to determine the conditions under which satisfactory control can be assured. Some six elements of these conditions need to be considered separately and in combination:

1. Selectivity of 2,4-D and 2,4,5-T for woody plants.
2. Season and stage or condition of growth.
3. Efficiency of application (coverage).
4. Combinations of chemicals.
5. Concentration of solution.
6. Kind of vehicle.

With few exceptions tests have not been thorough enough to include in any one series adequate answers to the effects of all these six. Failure to consider them all has led to the inevitable and oft-quoted conclusion, "these chemicals show great promise, but further work is required---". This is a principal reason for not yet having completed our promised manuscript on the use of chemicals for control of forest vegetation.

Water and Chemicals for Fire Suppression

During 1948 the Experiment Station collaborated with the University of California at Los Angeles in fundamental studies of wetting agents for fire suppression. This study is financed in part by the Fire Control Equipment Development Project.

In February 1949, laboratory and field aspects of the study were taken over by the Station. Work completed at the University at that time showed two important things: (1) the theoretical minimum (ideal) volume of water required to cool a unit-volume of wood below the rekindling point, and (2) direct contact of water droplets on a burning wood surface is possible, thus permitting initial wetting and direct cooling of the burning wood surface.

Subsequent work at the Experiment Station during the year was divided into three parts: (1) measurement of the surface tension, spreading, penetrating, and foaming qualities of 14 commercial wetting agents; (2) further development of laboratory apparatus for obtaining standardized measurements of the flame-suppressing qualities of wet water solutions and gathering laboratory fire-suppression data; and (3) suppression and mop-up tests in the field to confirm and extend laboratory results.

Conclusions drawn from work performed to date are: (1) savings up to 25 percent in the volume of water required for mop-up can be obtained with wetting agents if applied with reasonable efficiency; (2) wetting agent solutions are markedly superior to plain water in their ability to knock down flames quickly, thus permitting access to a fire edge not otherwise accessible; (3) dead fuels, for example, along the burning edge of a fire or along a backfire line when sprayed with wet water remain wet for a significantly longer time than when sprayed with plain water; (4) fuels once treated with wet water and allowed to dry may be sprayed later with plain water with results comparable to an original spraying with wet water.

Enough progress was made in the study during the past year to conclude that wetting agents do have a definite place in fire fighting. Still undefined, however, are such important questions as the level of efficiency in application of water or wetting agent solutions that should be set as objectives for field practice, the times and places that wet water should or should not be used, and the detailed specifications of wetting agents that should be established for large-scale purchases.

Fire Danger Rating

Detailed analysis was made of the fire danger records of four northern California national forests for the last four years. The data were analyzed in a number of ways in an attempt to relate fire occurrence and area burned to different levels of danger. The results showed that the number of fires per day is nearly equal for all classes of fire danger. In other words, fire occurrence does not increase with fire danger on these forests. Neither does it increase on weekends or holidays. The chances that a fire may become a large fire, on the other hand, increase progressively as danger increases. Because of large variations in suppression efficiency, however, the data showed no statistically significant relations.

Large-fire Organization

A start was made on reanalysis of management problems in large-fire organizations, through participation in boards of fire review and study of on-the-ground practices. Observations on three project fires showed two particular weaknesses: failure to implement good organization structures and failure to use all available technical tools in planning strategy. Available information about the fire and about the manpower and equipment on hand are too frequently not used to fullest advantage. This is currently resulting in excessive suppression costs. Further study is needed to ascertain the full scope of the problem and to define organization and management principles that will correct these faults. Both definition of the problem and its solution will require close coordination between forest administration and research personnel engaged in the study.

Plans for 1950

1. Fire Damage Appraisal

Continue the adaptation of known principles of fire effects in setting up a comprehensive fire damage appraisal system for northern California. The objective is to develop principles and methods that will have universal, rather than only local, application.

2. Chemical Control of Vegetation

Continue on the same basis as last year, keeping currently posted on developments and advising forest administration on recommended practices. Only sufficient pilot work will be done to provide checks on proposed treatments.

3. Water and Chemicals for Fire Suppression

If Fire Control Equipment Development Funds are again available, this study will be carried forward an additional step. Particularly, more information will be secured on such things as the effects of different pressures and discharge rates and patterns on suppression effectiveness for different fire problems.

4. Forest Fire Behavior and Control

Continue analyses of fire behavior data already on hand and publish the major findings that have practical value for field application. As opportunity permits, resume study of forest fuels to ascertain the effects of pertinent fuel factors on fire behavior. This will ultimately provide the basis for classifying fuel types according to rate of spread and difficulty of control characteristics.

5. Fire Danger Rating

Continue analysis of past fire and fire danger records to further strengthen potential uses of fire danger measurement in fire control management practices.

6. Large-fire Organization Management

Continue field studies of large-fire organization structure and functions of on-the-line and behind-the-lines overhead units. The problem is to find the critically weak spots and devise ways of eliminating them in the interests of smaller burned area and lower suppression costs.

FOREST ECONOMICS
(A. E. Wieslander, Chief of Division)

Objectives for 1949

1. Forest Survey

Inventory

a. Complete classification of age and density of timber stands from aerial photos for 75 quadrangles (3.0 million acres) and transfer these classifications to base maps.

b. Complete volume sampling for 6.0 million acres of commercial forest land.

c. Complete area and volume compilation for 6.7 million acres, including 6 complete counties, portions of 4 others, and 1 subregion.

d. Compile growth data on punch cards for 9.0 million acres.

e. Adjust general form-class volume tables to survey sample-tree data for major coniferous species and localize volume tables for one subregion.

f. Prepare volume tables for second-growth redwood in Scribner Dec.C and International 1/4-inch log rules, and for cubic sawlog volume and cubic volume to 4-inch top.

g. Complete compilation of fire mortality data and compile natural mortality estimates for Coast Range Pine subregion.

h. Determine sampling errors by age-density classes, and compile average volumes and coefficients of variability by stand classes, for area sampled through 1948.

i. Compile average 10-year growth and coefficient of variability by stand classes, for area sampled through 1948.

j. Devise site classification for old-growth redwood; also map redwood sites.

k. Prepare factors for converting old-growth redwood volumes expressed in Spaulding rule (equivalent to Scribner) to International 1/4-inch rule and to cubic volume, and compile volume estimates for old-growth redwood adjusted to survey standards.

l. Prepare mensuration sections of survey manual, proposed for both intensive and extensive surveys, and revise other sections of manual as necessary.

m. Plan the Survey's county statistical and subregion analytical reports; prepare Siskiyou, Trinity, Lake, Napa, Glenn, Sonoma and Colusa County reports for release; and assemble general descriptive material for the Coast Range Pine subregion report.

Drain and Requirements

n. Complete field work for logging waste study of 5 large operations; compile results; and produce report on this phase of drain for both pine and redwood regions.

o. Conduct a sample canvass of lumber production for 1948 in the 7 southern counties of the redwood region, and supplement the canvasses of the West Coast Lumbermen's Association and the Western Pine Association in the pine region.

p. Conduct a survey of production of plywood, veneer, cooperage, and pulpwood for 1948.

q. Compile results of Station and Association production surveys, and publish results as a Station Research Note.

r. Cooperate with the Washington Office in making as complete as possible their survey of wood used in manufacture in 1948. This mainly involves the secondary wood-using plants.

2. Forest Economics Research

Continue informal cooperation in the study of the economics of sugar pine management and blister rust control. During the coming year, emphasis in this project will be devoted to (1) completing the analysis of the effects of stand age, density, type, and site on costs of management and blister rust control, and (2) developing a basis for classifying cut-over lands in terms of the economic feasibility of managing sugar pine thereon.

3. Other Activities

a. Continue State Division of Forestry cooperation, including:

Intensify the classification of timber cropland, range, and watershed land from aerial photographs for 75 quadrangles (3.0 million acres) included under (a) of Inventory plans for 1948.

Complete the field work for type and site mapping and soils classification for 1.0 million acres (29 quadrangles).

Prepare for distribution 160 Timber Stand maps (5.8 million acres) and 40 Vegetation and Soil maps (1.4 million acres).

Compile ownership acreages for southern Mendocino County and prepare preliminary report of ownership for the entire county by combining the results of this study with the one previously made for the northern part of the county.

Revise the field manual for vegetation and soils mapping as needed.

b. Conduct a training school in photogrammetry and photo classification techniques for new survey personnel.

c. Keep cooperative ownership study with the BAE abreast of the field and office work in the inventory. Compile punch cards of ownership data for 7 counties (6.6 million acres) and complete the field survey of type, size, value, and intent of ownership for an equivalent area. Prepare ownership reports as supplements to county statistical reports (areas and volumes) to be released during the year.

d. In cooperation with the Northern Rocky Mountain Forest and Range Experiment Station prepare a detailed survey work plan for the area remaining in the Rocky Mountain territory, Regions 2, 3, and 4.

Activities and Accomplishments

Forest Survey--Inventory

Photo Classification.--Classification of age and density of timber stands from aerial photos was completed for the equivalent of 75 quadrangles as planned. However, new classifications were made for only 60 quadrangles (2.4 million acres). The remaining 15 quadrangles were represented by revision of previous work; this was done to bring the old work into agreement with unanticipated new photography and to correct for misclassifications by inexperienced personnel engaged at the start of the survey program.

Working on these classifications and those accumulated in the previous calendar year, the drafting room exceeded its 75-quadrangle objective for transfer of photo classifications to base maps. The 1949 work consisted of 64 new quadrangles (2.6 million acres) and revision of work for 20 quadrangles (0.8 million acres) in which photo classification had been previously revised. By the end of 1949, 46 percent of the transfer job for the entire survey program was completed.

Volume Sampling.--Because volume and growth sampling was proceeding faster than related inventory operations, this phase of the work was purposely held back to 73 percent of the objective for the year. Samples were measured for 4.6 million acres rather than the 6 million originally planned. One man was assigned to mensuration operations, another to State cooperative projects, and two (instead of one as originally planned) attended the statistical school in Washington. Cumulative progress to the end of the year represents 84 percent of the sampling job completed.

Area and Volume Compilation.--Area and volume data were placed on punch cards and tabulated for an average of 3.8 million acres, a little more than half the objective. Work completed in the three major phases of this job was:

Area measurement . . (80 quadrangles) . . .	3.2 MM acres
Area compilation	3.7 MM acres
Volume compilation	4.3 MM acres
Average	3.8 MM acres

This work (and the growth compilations) was slowed because some effort was diverted to place fire mortality data on punch cards, to revise previous estimates, or to measure areas outside timber cropland boundaries for report purposes. Status of the work in specific areas by the end of the year was:

All area measurement completed for the Coast Range Pine subregion and part of the Redwood--Douglas-fir subregion.

Area measurement and preliminary compilation completed for Siskiyou, Trinity, Lake, Napa, Glenn, Colusa, Mendocino, and western Shasta and Tehama Counties.

Final area tabulations completed for Siskiyou and Trinity Counties and for the Coast Range Pine subregion portion of Siskiyou County.

Volume calculations completed and placed on punch cards for all trees in Coast Range Pine subregion.

Tree volume data placed on punch cards for Redwood--Douglas-fir subregion.

Editing and coding of volume data for use on punch cards started for the Eastside and Westside Pine subregions.

Growth Compilation.--Growth data were compiled for the equivalent of 6.4 million acres. This consisted of punching volumes and growth increment for four kinds of volume in cards for all trees recorded on plots in the Coast Range Pine subregion. The objective was 9 million acres, but some planned work was deferred in favor of completing the analysis for fire mortality and to permit preparation of punch cards of data needed for volume table work.

Volume Tables.--Existing general form-class tables were adjusted to local survey data as planned: localized tables were completed for the Coast Range Pine subregion, including eight major coniferous species. In addition, basic form-class tables were constructed for four major hardwood species and prepared for publication as a Station Research Note. These will be the first tables published for California black oak, Oregon white oak, Pacific madrone, and tanoak. These tables, in turn, were adjusted to fit local data for an additional 9 species entering into volume calculations.

The objective of preparing volume tables for second-growth redwood was also met. These tables, too, were prepared for Station

publication; they incorporate form-class and include measurements of larger trees than were used in constructing earlier tables.

Mortality Compilation.--Compilation of fire mortality data and calculation of sampling error for the State was completed. The fire mortality data was put on punch cards and compiled by the tabulating section, a job not planned for the year. A mid-year review of the work showed that the card system should be used, and it was decided that this job should be done at once. Natural mortality compilation, however, was deferred in favor of work on volume tables and cull factors. Final compilations of natural mortality will benefit from a series of large permanent mortality plots established by the Bureau of Entomology and Plant Quarantine during the last half of 1949. These plots will augment the meager data obtained on survey plots.

Sampling Error Determination.--Data for compilation of sampling errors, by age-density classes, and average volumes and coefficients of variability by stand classes was placed on punch cards but summaries were deferred in favor of area compilations required for reports.

Ten-year Growth.--The 10-year growth by stand classes for the Coast Range Pine subregion was placed on punch cards, but sampling error compilations were deferred to permit area compilations for report purposes.

Redwood Site Classification.--Site classification for old-growth redwood was deferred in favor of projects of higher priority.

Converting Factors.--Factors for converting old-growth redwood volumes from Spaulding rule, International 1/4-inch rule and cubic volumes, and the compilation of volume estimates for old-growth redwood were deferred to 1950.

Manual Revision.--Amendments to the field manual have been prepared as needed and will be incorporated into the manual when it is revised.

Survey Reports.--Plans for statistical and analytical reports were completed, but preparation of the reports was retarded by reorganization of the survey staff to fill vacancies caused by Jensen's resignation and Hasel's transfer to the Region.

Three kinds of reports are needed to cover Survey activities: (1) Statistical reports, which will show forest areas, forest land ownership, and timber volumes for counties, and this information plus growth and commodity drain for subregions and the region; (2) Analytical reports, which will present the basic statistics with an analysis of their importance in management of timber and other forest resources for subregions and the region as a whole; (3) Special reports, which will make available to practicing foresters the techniques and results of studies undertaken as part of the survey job.

One report was completed by the end of the year: a statistical report of forest areas and forest land ownership in Siskiyou County. Some highlights of the findings for this county are:

> Siskiyou is our leading timber county in terms of forest and commercial forest land acreage. It ranks second in standing board-foot timber volume. Most of its timber in the rugged western portion is as yet untouched. About three-fourths of the forest land in the county will produce timber crops and about four-fifths of the timber cropland is stocked with commercial saw-timber stands. Most of the saw-timber is young growth.
>
> Public agencies own three-fourths of all land in the county, two-thirds of the commercial forest land, and two-thirds of the saw-timber acreage. Public ownership is almost all national forests. Timber operators and timber holders control more than four-fifths of the privately owned old-growth saw-timber stands and almost three-fourths of the young growth saw-timber stands, and most of these holdings are in units of 50,000 acres or larger.

A similar report for Trinity County was well along towards completion at the year's end. Reports were started for Glenn, Colusa, Lake, and Napa Counties and the Coast Range Pine subregion. The subregion report will include areas and volumes.

Two special reports were considered. One is a brief description of the Forest Survey in California: how it is authorized, administered, and conducted, what agencies are cooperating, its present status, and how available information may be obtained. This was completed with the Siskiyou County report. The second, on how to inventory a forest property, is intended as a handbook for practicing foresters. It will feature the use and advantages of aerial photos and statistical sampling. Work on this report was started late in the year.

Forest Survey--Drain and Requirements

Logging Waste Study.--Field work was completed for a logging waste study of 5 large redwood operations, involving 30 debris plots and 30 felling plots, all in difficult terrain. However, the data were only partially compiled and the reports were not completed. The time required for surveys of lumber production and wood used in manufacture was more than anticipated; this prevented compilation of waste data. The report on Redwood Region woods waste was deferred until 1950, when the data will be fully compiled. We overestimated our capabilities by including the Pine Region woods waste report as an objective for 1949.

Lumber Production Survey.--The survey of 1948 lumber production was completed as planned. Work required for this job included a sample canvass of the seven southern counties of the Redwood Region,

a canvass supplementary to that of the West Coast Lumbermen's Association in the two northern counties of that Region, and supplement to the Western Pine Association canvass in the Pine Region. As an aid in conducting these lumber production surveys, our sawmill lists were brought up-to-date to the extent possible by correspondence in the Pine Region and supplementary field work in the Redwood Region.

Survey of Other Forest Products.--A survey was conducted covering the production in 1948 of logs for plywood, veneer, pulpwood, and cooperage. The results were compiled and released as Forest Research Note No. 63. Highlights: production of logs for plywood showed an almost five-fold increase over 1946, amounting to 71,315 M bd. ft. in 1948. Only 2 plants operated in 1946; 9 were operating in 1948.

1948 Lumber Production Report.--The results of the three-way sample canvass of 1948 lumber production were compiled and released as Forest Research Note No. 65. Highlights: California produced an estimated 3,962,910 M bd. ft. of lumber, to exceed all previous records for a third successive year. For the first time California surpassed Washington as the second lumber-producing state in the nation.

Survey of Wood Used in Manufacture.--Assistance was provided to the Washington Office in a survey of wood used in manufacture in 1948. This involved editing and coding about 1,275 mail returns, and canvassing in the field (with some help from Region 5) about 175 operators as a sample of nonrespondents to the mail canvass. The latter group was also edited and coded, making a total of 1,450 returns handled.

Forest Economics Research

The Division continued to cooperate informally with members of the staff of the School of Forestry in the study of the economics of sugar pine management and blister rust control. One member of the Division staff was loaned to this project for three weeks on a reimbursable basis to assist in field collection of sample plot data. Another member assisted for a comparable period in the compilation and analysis of field data. In addition, type maps, aerial photos, statistical data, and other Division work materials were made freely available.

Accomplishments of the economic study during the year included completion of a field survey covering a sample sugar pine management unit on cut-over land, partial analysis of these field data, and the development of standards for use in classifying cut-over sugar pine land in accordance with its desirability for management and blister rust control.

Other Activities

State Cooperation.--The photo classification of timber, range, and watershed land was intensified from 40 to 10 acres for 77 quadrangles (2.8 million acres). This slightly exceeded our planned objective in number of quadrangles.

Species types, sites, and soils classifications were mapped in the field on 24 quadrangles (almost 1 million acres), 5 short of the objective.

Seventy-eight timber stand maps were prepared for printing and distribution. In addition, 11 vegetation-soil maps were prepared for distribution, together with legends and tables containing the following information: (1) General information on vegetation, soils, and site classification, (2) illustrative glossary of botanical terms, (3) map legend for plant species and miscellaneous elements, with growth characteristics and browse value of each species, (4) recognition key for each species mapped, (5) map legend for soil series with a tabulation of soil characteristics, and (6) rating of relative suitability of the soil series for timber and grass production. The output of completed timber stand maps, although less than planned, was commensurate with the progress of photo delineation and the production of needed base maps. Publication of vegetation-soil maps did not proceed as rapidly as expected primarily because most of the map units represented some of the first work in the project; it was necessary to subject this work to unusually close field and office scrutiny before final release.

The ownership study for southern Mendocino County was completed, but no report was issued combining the results with the northern Mendocino results because such a report was not contemplated. This objective was erroneously listed for 1949.

The field manual for vegetation and soil mapping was revised and brought up-to-date, as needed. In cooperation with the Bureau of Plant Industry, Soils and Agricultural Engineering, three new soil series were correlated, and the descriptions of 15 others revised. Three additional new soils series have been mapped and their correlation is pending by Bureau of Plant Industry.

Other assistance requested by the State was for soils work on the Williams Ranch in southwestern Shasta County. This involved mapping vegetation and soils for about 8 sections of land. The work was preparatory to a State and private range study and improvement project.

Techniques Training.--Two training schools were conducted during the year. One was for Division and Regional personnel; it covered photogrammetry, techniques for classifying land and vegetation, and photo interpretation techniques. Another, held in cooperation with the University of California, School of Forestry, was conducted to instruct personnel of public agencies and private industry in the use and application of aerial photos. A short field course was held for students of the Division of Soils, University of California, covering vegetation classification and soil mapping techniques.

Bureau of Agricultural Economics Cooperation.--Ownership data gathered in the field were consistent with the progress of inventory coverage. According to plan, the information gathered during the year (for four counties) together with data collected previously for

three additional counties was placed on punch cards and compiled in a form that coincided with area statistics of type and stand-size class. The ownership information for the Siskiyou and Trinity County reports was completed for publication.

Rocky Mountain Plan.--Burks, with Dickerman of the NRM in Missoula last February, prepared the survey work plan for the Rocky Mountain Territory in Regions 2, 3, and 4. It covered such items as allowable funds, accuracy controls and specifications, discussion of alternative survey methods and research needed to test the merits and practicability of these methods, or to develop improved techniques, organization, and division of work, and probable costs and required allotments by years and by States and cooperating stations.

Special Soil Studies.--To supplement and increase the value of the vegetation-soil maps being produced through State cooperation, two field studies of a week's duration were made. These studies were not contemplated in the plans for the year. The objective of the first study was to determine whether the survey's soil classification would have significance in watershed management. Soil scientists from the University of California and the U. S. Department of Agriculture (BPISAE), and hydrologists from the Station and Region 5 described and studied the soils at 32 locations in the Coast Range area. For each soil class the hydrological characteristics of the soil and the upper rock substratum were recorded; also, the permeability and erodibility of each soil were evaluated under natural cover, cultivation, and grazing, and after logging, clearing, or burning. It was evident from this preliminary study that the maps would be useful working tools in watershed management.

In the second study the objective was to rate soils for grass production. The participants were soil scientists from the University and U.S.D.A.; range technicians from the Station, Region 5, State Division of Forestry, and the University of California; and land appraisers from the Division of Assessment Standards, State Board of Equalization. Altogether the soils at 39 locations in the Sierra Nevada foothill area were described, identified, and rated for grass productivity. These preliminary ratings graded the soils in six productivity classes as follows:

		Acres per cow year
I.	Very good	Less than 12
II.	Good	12-18
III.	Fair	19-30
IV.	Poor	31-48
V.	Very poor	49+
VI.	Unsuited	- - -

Although the study was preliminary, it was the consensus of the group that ratings of this kind would increase the value of the vegetation-soil maps for range management purposes.

Plans for 1950

1. Forest Survey--Inventory

a. Field Operations.--Complete classification of age and density of timber stands from aerial photographs for the Redwood--Douglas-fir subregion and extend this work into foothill area at the north end of the Sacramento Valley. Develop techniques according to Manual specifications for volume and growth sampling of old-growth stands in the redwood type, establish plot locations, and take as many plots as may be feasible.

b. Office Operations.--Transfer photo classifications to base maps for the Redwood--Douglas-fir subregion and the foothill area at the north end of the Sacramento Valley. Complete area, volume and growth compilations for the Coast Range Pine subregion and start this work in the Redwood--Douglas-fir subregion.

c. Mensuration Operations.--(1) Adjust standard volume tables to apply to survey plot data in the Redwood--Douglas-fir subregion. (2) Prepare separate estimates of fire mortality and natural mortality for Coast Range Pine and Redwood--Douglas-fir subregions. (3) Calculate sampling accuracy of estimating the area of commercial forest land and volume of timber in the Coast Range Pine subregion. (4) Compile average 10-year growth and sampling accuracy for commercial forest stands in the Coast Range Pine subregion. (5) Develop factors for converting old-growth redwood volumes from Scribner Decimal C rule to International 1/4-inch rule and to cubic volume.

d. Drain and Requirements.--Complete compilation of redwood region logging waste data.

e. Reports.--Carry as far forward as possible the preparation of statistical reports covering forest areas and timber volumes for the Coast Range Pine subregion and forest areas and forest land ownership for Trinity, Glenn, Colusa, Lake and Napa Counties.

Publish report prepared by J. W. Kimmey, Forest Pathology, Bureau of Plant Industry, of cull factors and cull indicators for Douglas-fir and red and white fir and cull factors for the pines, in the Coast Range Pine and Redwood and Douglas-fir subregions. Issue circular describing the Forest Survey in California.

2. Forest Survey--Other Activities

a. State Cooperation.--Intensify forest survey photo classifications dealing with timber, range and watershed lands for the area included under Inventory 1 a. Complete the field work for type, site and soils mapping for Mendocino County and for about the south half of Humboldt County. Prepare for distribution timber stand maps for the state area in the Redwood--Douglas-fir subregion and in the foothill area at the north end of the Sacramento Valley, and vegetation-soil maps with accompanying tables and legends for Mendocino County.

In cooperation with the Bureau of Plant Industry, Division of Soils, prepare and publish an article on podzolic soils and associated vegetation.

Conduct a special training school in cooperation with the State Division of Forestry and Division of Soil Technology, University of California. This school will be for the purpose of instructing certain State Division of Forestry personnel and representatives of other State and Federal agencies in the value of the timber stand and vegetation-soil maps as working tools in resource management.

b. Bureau of Agricultural Economics Cooperation.--Keep cooperative field ownership survey abreast of the field and office work in the inventory, and complete compilation of ownership data for the Coast Range Pine subregion and begin work in the Redwood--Douglas-fir subregion.

3. Forest Economics Research

Continue informal cooperation in the study of the economics of sugar pine management and blister rust control. During the coming year the following phases of this project will receive primary emphasis: (1) Expansion and refinement of the classification standards to be applied to cut-over areas, (2) application of these standards to the Eldorado County study unit, and (3) preparation of a progress report summarizing the accomplishments and findings of the project to date.

FOREST UTILIZATION SERVICE
(L. N. Ericksen, Chief of Division)

Objectives for 1949

1. Seasoning of Wood

a. Continue experimental work in kiln drying California black oak.

b. Development of better kiln schedules for white fir.

c. Endeavor to develop techniques for better control of brown stain in pine.

d. Study basic principles in drying with direct-fired as compared with indirect heated dry kilns. (In the former the combustion gases are exhausted into the kiln chamber and in the latter steam-heated coils placed in the kiln are the heat source.)

2. Utilization

a. Develop better techniques for resawing white fir. (Would be an FPL project.)

b. In cooperation with FPL develop better nailing techniques for assembly of lightweight agricultural boxes.

c. Hold a wood-conditioning and gluing conference if interest in southern California warrants.

d. Develop information on optimum conditions for production of veneer from redwood; also study veneering of Douglas fir from Sierra Nevada.

e. Work with College of Agriculture, University of California at Davis, on analysis of wood sugar molasses and preliminary feeding tests.

Activities and Accomplishments

Seasoning

Black Oak.--A year ago we reported on the successful air seasoning and subsequent kiln drying of California black oak in the form of 3/4-inch x 3-inch flooring strips. During the past year further work was done to determine whether 4/4 black oak of random widths and lengths could be successfully seasoned. The work was done at the plant of a cooperating mill at Oroville, the oak coming from the west side of the Sierra Nevada about 30 miles northeast of that town. The lumber was sawed and placed in the air-drying yard in August, when high temperatures and low humidities are customary. The lumber was air seasoned without perceptible surface checking and with only a moderate amount of end checking. During 63 days in the yard, the lumber dried from an average moisture content of 98.5 percent to 17.3 percent.

After preliminary experimental runs in the small portable kiln furnished by the Forest Products Laboratory, the bulk of the lumber was dried in the company's commercial kiln. This is a conventional steam-heated, cross-circulation kiln. The air-dried stock was successfully kiln dried in $7\frac{1}{2}$ days without loss due to drying defects. We have put this lumber producer in touch with a Los Angeles hardwood wholesaler who is interested in getting this stock into the industrial trade to determine its suitability and acceptability in fabricating furniture and other items.

One attempt to kiln dry oak green-from-the-saw was unsuccessful, due to excessive collapse and warping. This occurred even though mild initial temperatures (120° F.) were used.

In view of the work done on 3/4 and 4/4 stock we feel that this species can be successfully seasoned by established conventional methods of air seasoning and kiln drying and that seasoning need not be a retarding factor in its utilization.

White Fir.--A small amount of experimental work was done, using the Forest Products Laboratory's small kiln, on the kiln drying of white fir. The results support our recommendations of a relatively severe drying schedule now used extensively throughout the industry. Further work is needed to determine the drying rates for different thicknesses. Greater kiln capacity may result from drying thinner sizes than the conventional thick box lumber.

Brown Stain.--Research to determine the causes of brown stain, particularly in sugar pine, was begun in cooperation with the Forest Products Laboratory. The F.U.S. unit arranged with several pine mills to bring in and saw sugar pine logs which had been left in the woods, along rights-of-way, or in the pond for considerable periods. The FPL sent M. A. Millett of the Division of Derived Products to the Institute of Forest Genetics at Placerville, where extractions of the wood from these logs were made after it had been determined that the wood was susceptible to brown stain. Other extractions were made from freshly cut and sawed sugar pine that had been shown by drying to be less susceptible to brown stain. All these extractives were taken back to Madison for analysis and study of staining characteristics.

Greater quantities of extractive materials were obtained at high temperatures (1.62 percent at 212° F. and only 0.87 percent at 100° F.). Sitka spruce blocks impregnated with this extract of sugar pine stained more when dried at high temperatures than at low temperatures. Both results indicate the desirability of low temperatures during kiln drying, thus reducing the amount of stain-producing substances that goes into solution and the intensity of the brown staining that may develop. Further work of this kind is planned for the coming year, since it is felt that this chemical stain can be better controlled if its origin and nature are better understood.

Direct-fired Kilns.--Observations have been made on the operation of direct-fired kilns throughout the state. At least eight types are in use in California, and several companies are now prepared to sell this equipment. Additional direct-fired kilns are being installed both in the Los Angeles area and in the northern part of the state by industrial firms and custom dry-kiln operators. The quality of drying varies considerably; some is apparently comparable to the best drying in the more conventional steam-heated kilns.

Pine lumber dried in kilns heated with fuel oil has showed some red or pink stain. Although this probably has no effect on the properties of the wood, it is objectionable to some users who are accustomed to the light color of pine.

Utilization

Sawing Technique.--Definite progress was made during the past year by the Forest Products Laboratory in the development of an improved saw. We are particularly interested in this as a means of solving some of the problems involved in the sawing of white fir. We have furnished material of different densities, rates of growth, etc., for use in the Laboratory's work on this problem. Although the Laboratory will report the results of the work in detail, we would like to mention briefly that the type of saw developed has alternate teeth filed and fitted differently, one set doing the lead cutting and the alternate teeth cleaning up the sides and bottom of the cut. A thinner kerf is possible, a smoother cut is made, and considerably less power is required with the new type of tooth. It may be used on either circular or band saws. Trial and demonstration under regular operating conditions are planned for the coming year.

Nailing Techniques.--During the past year the Forest Products Laboratory installed a nailing machine that will make it possible to duplicate nailing practices followed in assembling agricultural and industrial boxes. Also a member of the staff of the Laboratory's Container Division in company with F.U.S. men visited a number of box shook and box assembly plants to observe current practices and discuss nailing problems with operators. Experimental work is planned for the coming year on several specific problems.

Conditioning and Gluing Clinic.--Because of apparent lack of interest by furniture and allied industrial manufacturers the wood conditioning and gluing clinic tentatively planned for the southern California area did not materialize. There are no plans for this activity for the coming year.

Veneer Production.--Plans for last year included some work at the Forest Products Laboratory on the cutting and drying of rotary veneer from redwood and Douglas fir. Owing to inability to arrange for a cooperator to furnish the necessary material, this work is deferred until such arrangements can be made.

Molasses from Wood.--The experimental feeding of wood-sugar molasses being carried out in various parts of the country have been discussed with members of the staff of the Animal Husbandry Division, University of California, at Davis. Because of the low price of Hawaiian molasses laid down

in California, wood-sugar molasses would probably have difficulty in competing here. If the wood molasses is found suitable for feeding to livestock in greater quantities than cane molasses, it might have definite advantages. Quantities of wood molasses sufficient for analysis and small scale preliminary tests will be furnished to the College of Agriculture for such studies as they may care to make.

Other Activities.--An active interest in wood utilization and the possibilities for a broader utilization base has been shown throughout the year in the region. We have been consulted by and have worked with a number of operators seeking means of better utilization. The questions involved have covered a wide range, including air seasoning, kiln drying, wood preservation, outlets for sawmill waste, slabs, sawdust, and shavings, and properties and uses for different woods. Several companies interested in establishing plants using wood have inquired concerning supplies and possible plant locations. Several lumber-producing companies have installed equipment to manufacture cut stock. A number of new dry kilns have been installed, and we have had several inquiries as to the possiblilities of manufacturing board products from offal now going to the burner.

We have continued to work with and encourage the local dry kiln clubs, which meet periodically to consider seasoning problems in an effort to improve drying practices. The meetings of the Central California Dry Kiln Club during the past year were organized and directed from this office.

Manufacturers of redwood lumber are showing a definite interest in extending their utilization to the chemical and wood fiber fields. We have worked with them on a number of problems involving cooperative work between the California Redwood Association and the Forest Products Laboratory.

The pulp mill which went into production during the year (the only pulp mill in the state) is purchasing chips produced from slabs and edgings at seven sawmills in the Sierra Nevada region and is thus providing an outlet for some material formerly burned.

Plans for 1950

1. Continue research on causes and control of chemical brown stain of sugar pine.

2. Survey air-seasoning practices with special reference to handling and piling in unit packages.

3. Study distillation and carbonization of wood waste in Forest Products Laboratory's new continuous equipment.

4. Work with the University of California at Davis on wood-sugar molasses for experimental livestock feeding.

5. Continue study of resawing of white fir.

6. Continue work on nailing of fruit and vegetable containers, with special emphasis on white fir.

7. If necessary cooperation can be arranged, study cutting and drying of redwood veneer in cooperation with Forest Products Laboratory.

8. Study use of pecky incense cedar for core stock for doors and furniture tops, in cooperation with Forest Products Laboratory.

RANGE RESEARCH

(M. W. Talbot, Associate Director, In Charge)

Objectives for 1949

1. Mountain Ranges

a. Complete the manuscript covering the major findings at the Burgess Spring Experimental Range.

b. Continue assistance in developing the artificial reseeding program in northeastern California.

2. Foothill Ranges

a. Submit final manuscript on management of annual-plant ranges for publication as a Departmental circular.

b. Summarize results from supplemental studies of range fertilization and reseeding and publish in technical journals or agricultural press.

c. Survey the set of small pastures intended for detailed studies, including measurement of site classes and rock or tree cover, and measure total herbage production of each pasture at plant maturity.

d. Develop additional techniques for forage growth measurements needed in the detailed pasture studies.

e. Prepare detailed study plans for the small-pasture studies of fertilization and rodent control and start the work.

f. Intensify studies of fertilizer requirements of range forage on soils of granitic origin. Continue reseeding studies and limited liaison with brush-control studies.

3. Range Reseeding

a. Intensify study of sites for reseeding and study of species and strains for range use in lower pine forest and Great Basin sagebrush zones. With Hormay, develop plans for management studies of reseeded range areas in these zones.

b. Study time and rate of applying 2,4-D on different species of sagebrush, rabbitbrush, and certain meadow weeds to precede reseeding.

c. Compare different methods of preparing the land for reseeding on the San Joaquin Experimental Range.

d. Continue observation of pilot plot and field seedings made by Region 5 on the several national forests, and cooperate with other Federal and State agencies in coordinating plans for reseeding research.

e. Complete the writing of the State-wide problem analysis and work plan for the range reseeding project.

4. Brushland Improvement

a. Review the general status of brush control in California.

b. Coordinate the planning and initial work on this project with the activities of other agencies.

c. Start a set of field-plot studies and observations that will contribute useful information during the first season.

Activities and Accomplishments

Brushland improvement is a new project, added to the activities of the Division in 1949. This work started in July under authorization from the Research and Marketing Act. J. R. Bentley was placed in charge of the project, and objectives were set up for the remaining six months of the year. L. R. Green took charge of field studies in foothill grazing management.

Mountain Ranges

Burgess Spring Manuscript.--The size of the job load in the last stages of analysis was underestimated last year; however, by the end of the year analysis was completed for 14 years of research (1936-49) at the Burgess Spring Experimental Range on the management of northeastern California summer cattle ranges, and an initial outline for a Departmental circular as previously approved has been prepared.

Most of the 1949 season was spent in integrating the basic and specific research results on various phases of cattle range management into an over-all plan that insures both sustained forage production and efficient livestock production. This plan involves management of grazing and cultural practices like artificial reseeding and chemical spraying. To bring out its practicability considerable time was spent on an economic analysis. The results, although not final, show that under northeastern California conditions--where heavy investments are required in fences, water developments, and similar management facilities--it would pay a private operator to carry out the practices proposed. This finding will greatly enhance the practical value of the results to be reported in the circular.

Generally speaking, the work at the Burgess Spring Experimental Range has shown that range deterioration and inefficient range use stem largely from a lack of balance among the four major controllable factors of management: (1) stocking rate, (2) season of use, (3) frequency of grazing, and (4) livestock distribution. This lack of balance in turn arises from the lack of full appreciation of how the range is actually grazed and how the vegetation and livestock are affected. On northeastern California cattle ranges, for example, livestock distribution and frequency of grazing are very inadequately handled. Season-long grazing (the frequency-of-grazing factor), together with the characteristic uneven and fixed pattern of use suffered by cattle ranges, is a basic cause of range deterioration.

Efficiency in forage production depends on periodic resting of the range. Season-long resting and season-long grazing are important requirements. Efficiency in livestock production depends primarily on proper regulation of the season, intensity, and distribution of grazing. The system of grazing developed at Burgess Spring takes all these factors into balanced consideration. The principles that have been developed apply to the management of many ranges--both cattle and sheep--throughout the West.

The next step in the extension of Burgess Spring results rests on testing this plan on an actual range on a pilot plant basis. The reactions observed will then direct future research into the lines of study most needed to improve management.

Foothill Ranges

The transfer of Bentley to the new R&MA project at mid-year prevented completion of summaries and reports as planned; otherwise the objectives were fairly well fulfilled. At the end of the year final revision of the manuscript for a Departmental circular on management of annual-plant ranges, to take account of reviewers' questions and comments, was virtually completed. Redrafting of a few figures remains.

By straining all available resources the San Joaquin personnel made good progress in the establishment and calibration of the small experimental pastures and in further development of sampling techniques. Herbage yields were measured in 8 small pastures; site surveys and fencing were completed for 6 of these pastures; and cattle gains were recorded in 4.

Sampling Techniques.--An attempt was made to develop a more efficient method for estimating the yield of the individual components within a sample of total herbage production. The method must be more rapid than complete segregation and weighing of clipped samples, but must be sufficiently accurate for use in detailed plot and pasture studies. Both field and laboratory estimates of composition and weight were made. Partial analysis of the data indicates that weighing of each total quadrat sample and estimating the components by weight is an accurate and reasonably rapid method.

Rodent-control Pastures.--In two of the fenced experimental pastures, records were made of herbage yields, rodent populations (by Division of Zoology, University of California), cattle gains (by Division of Animal Husbandry, University of California), and degrees of utilization. The Division of Zoology was represented by Dr. Tracy I. Storer and Dr. Walter P. Howard; the Division of Animal Husbandry by Drs. George H. Hart, Elmer H. Hughes, Harold R. Guilbert, and Kenneth A. Wagnon.

One pasture, containing 40.4 acres, was located in an area that had been used moderately during the dry season. The other, of 48.5 acres, was in an area that had been closely grazed during the plant growing season. These were the only available areas with satisfactory rodent populations that were close to weighing facilities.

Records of gains of the 10 yearling heifers and of herbage yields showed that the two pastures must be calibrated for at least one more year before rodents are controlled.

Fertilizer Pastures.--One fertilized pasture and an unfertilized control pasture were fenced. Each was stocked with 10 head of weaner steers during the dry season, July 1 to November 3. Animal gains and herbage yields did not show any significant differences between pastures, indicating that the two were properly calibrated. Because of below-average yields, however, the pastures did not carry the steers until January. Provision for carrying the steers during part of the winter will have to be worked out.

Approximately 40 acres of the fertilized pasture could be covered with a tractor and drill. This portion was fertilized at the rate of 200 pounds superphosphate and 40 pounds of soil sulfur per acre. At the end of March the effect of fertilization was shown by the deeper green color of the legumes. The lack of effective rains from mid-March until mid-May, however, limited plant growth, and there was no significant difference in legume production between the fertilized and non-fertilized strips within this pasture, nor between fertilized and control pastures.

Two other pastures, which will be grazed during the green-forage season, were surveyed and yields were measured. Fencing will be completed and the pastures stocked during the 1949-50 season. One of these will be fertilized after the calibration is completed.

Reseeding Pastures.--One of the two small pastures that will be used to evaluate reseeding has been fenced. The survey and first-year measurement of herbage yields have been completed. Considerable change in the original plan for these pastures may be necessary if seed of adapted species cannot be obtained for the required acreage.

Now that the considerable work involved in selection and establishment of the small pastures is nearly completed, more manpower will be available for completion of the detailed study plans and for the conduct of specific studies within the pastures.

Range Fertilizer Requirements.--A new set of plots was established to determine the efficiency of different rates and combinations of gypsum, soil sulfur, superphosphate, and trace elements when applied for the stimulation of legume growth. The results will be of value in determining the fertilization procedures to use in the pastures. Results were about the same as those previously reported for the combination of superphosphate and soil sulfur: at plant maturity there were no consistent effects of fertilization that could be observed, even though higher yields of clover were measured in most of the fertilized plots as compared to adjacent check plots.

Observations on older plots supported previous conclusions that a fair or good clover year is needed to obtain a large increase in legumes through application of sulfur-bearing fertilizers on the sandy

loam soils at the Range, and that increase of forage from increased soil nitrogen will be limited on these soils during years that have short periods of severe drought.

Range Reseeding

Priority for reseeding research has been assigned to the depleted ranges in the Great Basin sagebrush and the lower pine-forest zone of northeastern California. Substantial benefits from reseeding are already apparent in these zones; forage yields on reseeded areas have been 3 to 13 times the production on adjacent depleted range. Encouraging progress has been made in developing better criteria for selecting suitable sites and species to be employed in reseeding programs for the two zones.

Suitability of Species and Sites.--Crested wheatgrass continued to give relatively high yields when compared to other species for early season forage production on the more arid areas below 5500 feet in elevation. Results in 1949 from 4-year-old plots on the Shasta National Forest are as follows:

Species	Forage (oven-dry) in pounds per acre from milacre quadrats clipped			Percent moisture (on dry weight basis)	
	June 18	Aug. 11	Sept. 30	Aug. 11	Sept. 30
Smooth bromegrass	703	570	413	17.23	10.89
Crested wheatgrass	1212	901	754	18.53	13.99
Big bluegrass	1258	1351	1140	22.94	24.74
Bearded bluebunch wheatgrass	1062	1039	930	10.66	10.59
Beardless bluebunch wheatgrass	-	970	-	11.93	-
Slender wheatgrass	800	645	-	11.34	-
Western wheatgrass	-	534	-	16.44	-
Least significant mean difference, 5 percent level		1/243		3.05	4.38

1/ For first four grasses listed for all three dates.

It will be noted that big bluegrass retained more moisture throughout the late summer season than the other species. Although big bluegrass makes most of its growth in the spring, it may fill a need for green succulent forage in late summer, when most range grasses are dry. Two recent introductions, intermediate and tall wheatgrass, also excelled in the ability to remain green. These two wheatgrasses had not been seeded in the older plots tabulated above, but they offer considerable promise for use in reseeding forest ranges.

On depleted ranges at elevations above 5500 feet, smooth bromegrass has been giving excellent results. Other grasses showing promise on well-drained sites are intermediate, pubescent, and tall wheatgrass; big bluegrass; slender wheatgrass; and mountain bromegrass. On moist sites, timothy, smooth bromegrass, meadow foxtail, tall fescue, and reed canarygrass are adapted. To permit more intensive comparison of strains and species a

planting was made in 1949 at the Halls Flat Nursery, Lassen National Forest, of 71 species represented by 173 strains.

Three sites have been selected for a special study on the Lassen National Forest. The kinds of sagebrush dominating the land before plowing and seeding are used to designate the three sites, namely, silver sagebrush, black sagebrush, and big sagebrush. Plowing with disc plow in the summer of 1947 gave a good kill of sagebrush in 1947.

A mixture of forage species drilled in the fall of 1947 gave an excellent stand on two of the sites but only a fair stand on the silver sagebrush site, which was submerged for 8 to 11 weeks during the wet spring of 1948. In 1949, a year with only 77 percent of normal precipitation, the yield was 619 pounds oven-dry forage per acre from big sagebrush site, 556 pounds from black sagebrush, and 312 from silver sagebrush. These figures reflect a several-fold increase in forage production over that on adjoining unseeded rangeland.

On the silver sagebrush site the soil is very heavy in texture, and the grass remained green about six weeks later than on the big sagebrush site, which has well-drained soil of light texture. The black sagebrush site is intermediate in soil texture and drainage. These three sites represent a high percentage of the depleted ranges in the openings of the pine forest of northeastern California. From information now available much of the reasonably rock-free areas of these depleted sagebrush ranges can be successfully reseeded. Present equipment cannot be efficiently operated on slopes greater than 40 percent. Also, some attention should be given to draining areas that may be submerged for more than 3 or 4 weeks in the springtime if such areas are to be reseeded.

Only cursory experimental seedings are being made at present in the mountain meadows on the west side of the Sierra Nevada in the pine forest zone, where conditions are rather humid (precipitation is 30 to 40 inches). The areas are less extensive and have lower priority for reseeding research than the depleted sagebrush range in northeastern California. Lodgepole pine encroachment presents a problem on many of the depleted meadows. A pilot test seeding was made on a representative meadow area in cooperation with the Sierra National Forest.

At the San Joaquin Experimental Range two native species, nodding stipa and purple stipa, continued to give the most satisfactory performance and persistence of all the species that have been tested on foothill range. A field seeded in 1946 to alternate rows of the two species of stipa has many plants that volunteered from seed produced the second and third year after the field had been drilled. A 1949 sampling revealed 70,104 first-year seedlings and 6806 second-year plants per acre. This natural thickening of the stand was accomplished in spite of strong competition from annual weedy plants. Several species of browse and a few Australian species of grass were transplanted from the greenhouse to the nursery in April 1949. Saltbush and native burro fat grew well and will be used as a source of seed for further testing. Three of the Australian grasses--Cenchrus biflorus, Danthonia richardsonii and Danthonia semiannularis--thrived without irrigation and produced seed.

Chemical Control of Competing Vegetation.--Big sagebrush proved highly susceptible to 2,4-D sprayed at moderate rates in 1948. Silver sagebrush was less susceptible; it lost much of the top growth but sprouted from the base of the stems. A count of dead and living plants and determination of the percentage kill of crown was made in 1949. The results for the Grass Valley area on the Lassen National Forest were:

Item	Pounds of butyl ester per acre 1/				
	1		5		10
Date of spraying	June 30	July 30	June 30	July 30	June 30
Big Sagebrush					
Percent of plants killed	85	81	100	92	94
Percent of crown area killed	95	95	100	99	96
Silver Sagebrush					
Percent of plants killed	3.5	30.1	29.2	51.3	25.5
Percent of crown area killed	18.0	89.0	66.0	97.0	71.0

1/ Twenty gallons of water used as a carrier.

Spraying big sagebrush with 2,4-D in June gave better kill than in July, but the later date was better for killing silver sagebrush.

A surprising increase in growth of remnant bunchgrass occurred on plots sprayed with 2,4-D. Measurements were taken in 1949 from plots sprayed with 3.3 pounds of butyl ester of 2,4-D per acre in June 1948. Crown density of live sagebrush diminished by 98 percent as a result of spraying, and grass production increased from 285 pounds per acre on unsprayed, to 642 pounds on sprayed plots. Portions of the range which are too rocky for drilling but have remnant bunchgrass can be substantially improved by spraying with selective herbicides.

Reseeding may be accomplished by drilling into the sprayed sagebrush areas, without plowing or burning, in the openings of the pine forest, where the sagebrush usually has low stature and moderate density. A comparison was made between drilling a mixture of forage grasses and legumes into the sprayed sagebrush plots and drilling into adjacent plots prepared by plowing unsprayed sagebrush. Autumn (1948) sowing gave 10.2 seedlings per square foot on the plowed plot and 8.8 on the sprayed plot. Spring sowing gave 5.0 and 6.2 respectively. These preliminary tests would indicate that depleted sagebrush range may be improved at less cost by spraying than by plowing to control the sagebrush.

A meadow area dominated by buttercup, camassia, knotweed, aster, and rushes responded favorably when 2,4-D was applied to plots in 1948. When treated and untreated plots were compared in 1949, basal density of weeds had decreased from 3.19 percent to 0.41 percent, and native grasses increased from 4.88 percent to 6.55 percent as a result of spraying. The grasses produced 1028 pounds per acre where plots were sprayed and only 242 pounds per acre unsprayed. Considerable bare soil still remained in the sprayed plots which had previously been occupied by the weeds.

Forage grasses and legumes were drilled into the sprayed strips in an effort to hasten conversion of the area to give maximum production of desirable forage. A satisfactory stand of seeded species was obtained. Another year will be required before the influence on forage production can be determined. A more complete test of 2,4-D on meadow weeds and on sagebrush was started during the summer of 1949 to answer some of the questions on rates, formulations, and dates of application. Preliminary observation would indicate that May and June application of 1 pound of the butyl ester of 2,4-D per acre gave satisfactory kill.

Land Preparation.--At the San Joaquin Experimental Range perennial grasses and legumes were drilled into three kinds of land prepared for reseeding: Summer fallow, sudan grass stubble, and annual range that had been sprayed with weed-killing oil. The objective was to determine the best means of reducing competition from resident annual weeds and grass. Conclusive results were not obtained because the season was deficient in rainfall and therefore unfavorable for germination and establishment of the plants. A noticeable reduction in annual weeds and grasses occurred during the spring, and through the fall and winter, on the plots sprayed with the special oil as compared with the portion of the field receiving no spray treatment.

Pilot Plots.--Silver sagebrush has been difficult to eradicate by one-way wheatland plow or by sprays. A reseeding test on the Modoc National Forest suggests that this species may be satisfactorily controlled by plowing with a heavy offset disc with cutaway blades. As revealed by the 1949 examination, a 95 percent reduction in silver sagebrush was accomplished and an excellent initial stand of grass was obtained on an area plowed and drilled as a pilot plot by the Forest and the Station in the fall of 1948.

The pilot plots selected by the Range Management Division of the Regional Office and National Forest in cooperation with the Station, are providing excellent examples of increasing forage production by reseeding on depleted range. The yield ratio in favor of reseeded areas, for example, was 3.3 to 1 on the Bolson tract, Plumas National Forest, and 12.7 to 1 on the Antelope Sink tract, Shasta National Forest.

Adverse conditions--including a loose, dry seedbed, unfavorable precipitation, and damage from rabbits--plagued the cooperative seeding test of crested wheatgrass near Fort Bidwell. One-third of the area, the portion seeded in the fall of 1948, had a fair stand of crested wheatgrass averaging 1.4 seedlings per square foot. The remaining two-thirds, drilled in the spring of 1949, failed and was replanted in October.

Test of Seeding Techniques.--Many questions arise concerning seedbed preparation beyond those concerned with the treatment required to control competition from undesirable plants. A complete series of treatments were included in a test of depleted sagebrush range on the Lassen National Forest to determine whether drilling alone is satisfactory on plowed land, or whether the rough plowed area should be disced and rolled ahead of drilling. Also, three types of disc openers were used on the drill in the experiment: the common single-disc openers, double disc with depth bands

for precision seeding, and deep furrow lister type openers. Each type of opener was used with and without press wheels. The emergence of seedlings in spring of 1950 will determine the relative value of the different treatments.

Problem Analysis and Working Plan.--The problem analysis has been completed. Progress has been made on the comprehensive State-wide plan for three line projects, dealing with species suitability, methods of seeding, and site selection.

Brushland Improvement

Review of Information.--Summaries of brush-control information collected to date by several divisions of the University of California and by some other agencies were assembled by the California Agricultural Extension Service. Bentley and Talbot contributed an article entitled, "Why Seed Brush Burns?"--a summary of observations made since 1941 in connection with foothill range research. The papers will be published soon as an Extension Service circular.

The general status of brush-control knowledge for the east side of the central San Joaquin Valley was summarized in cooperation with other agencies.

Coordination with other Agencies.--Good progress was made in coordinating the new Station project with the activities of other agencies. The sincere cooperative effort being put forth by each agency in the field will make for continually increasing efficiency in research. Professor B. A. Madson, University of California, serves as general coordinator for all agencies.

Plans for the first season were agreed upon; an integrated plan of work for the longer time program will be developed during the next year.

Field-Plot Studies.--Exploratory plots were established during the fall on burned-over, bulldozed, and disced areas at 13 different locations in 10 counties. The plots were selected in cooperation with the Extension Service and National Forest Administration. On most areas plots were established by two groups so that the work of one supplements the other. This close cooperation allowed sowing of larger areas, sampling of more sites, and increased efficiency in other ways.

Success of brush removal and grass establishment will be measured on selected plots under a variety of conditions over a period of years. The first season's results will help delineate sites and vegetative covers for which specific recommendations for brush removal can be made in the light of available information. These results will become apparent in the first half of 1950.

Specific objectives are: (1) to measure the herbage production potentials of different sites; (2) to determine whether a full herbaceous

cover retards brush re-establishment; and (3) to determine how quickly an established cover will stabilize the soil. Information will be obtained on methods of establishing superior forage species.

Plans for 1950

1. Mountain Ranges

a. Complete the Burgess Spring manuscript to make the major findings widely available and provide the basis for a comprehensive working plan for the next phase of the research program, which contemplates setting up a demonstration allotment for testing the findings to date.

b. Continue assistance in developing the artificial reseeding program in northeastern California.

2. Foothill Ranges

a. Continue calibration of small pastures. Apply fertilizer if cattle gains for one year show that the treatment and control pastures are sufficiently comparable.

b. Reorganize the data files and summarize additional data for publication.

c. Complete plans for, and as far as manpower permits, start new detailed studies on plant growth and utilization.

d. Submit final revision of San Joaquin manuscript.

3. Range Reseeding

a. Continue intensive study of sites and suitability of species and strains for forage in lower pine forests and the Great Basin sagebrush zone.

b. Compare dates and rates of applying different formulations of 2,4-D on sagebrush, rabbitbrush, and several meadow weeds on mountain grazing areas, and prepare a prelimimary report for publication on the work to date with 2,4-D.

c. Test several chemicals as preemergence sprays to kill annual weeds and grasses ahead of seeding perennial grasses and legumes on the San Joaquin Experimental Range. Also make a test planting of pampas grass at the Range.

d. Continue cooperation with Region 5 on the several national forests in observing pilot plot and field seedings and with other Federal and State agencies in coordinating plans for reseeding research.

e. Develop plans for a line project on management studies of reseeded range areas in pine forest zone of northeastern California and complete an over-all working plan for four line projects.

4. Brushland Improvement

a. Examine exploratory plots and prepare a report of first-year results. Continue studies on selected plots.

b. Develop a plan for future research integrated with work of other agencies.

c. Start a few long-term studies.

FOREST INFLUENCES

(E. A. Colman, Chief of Division)

Objectives for 1949

1. Continue the operation of the San Dimas Experimental Forest and the analysis of data from the area.

2. Complete for publication the following manuscripts:

"Trees and shrubs for erosion control in southern California mountains," by J. S. Horton.

"Rainfall interception by chaparral in California," by E. L. Hamilton and P. B. Rowe.

"Peak discharge and erosion rates from southern California watersheds as influenced by fire," by P. B. Rowe, C. M. Countryman, and H. C. Storey.

"Disposition of annual rainfall in two mountain areas of California," by P. B. Rowe and E. A. Colman.

Revision of the R-5 "Guide for sowing mustard....." to incorporate information on use of the helicopter, and recent changes in procedure.

3. Prepare manuscript reports on:

Development of vegetative cover following fire in the chamise-chaparral of southern California. (J. S. Horton and C. J. Kraebel)

The relation of fire to germination of chamise seed. (E. C. Stone)

Rainfall interception by second-growth ponderosa pine in California. (P. B. Rowe and T. M. Hendrix)

The storm vector. (E. L. Hamilton)

4. Continue study of rainfall measurement on the San Dimas Experimental Forest to improve the accuracy and economy of the job of rainfall measurement in mountain areas.

5. Continue the physiological and ecological studies of chaparral in cooperation with the Los Angeles River Flood Control Project and California Institute of Technology.

6. Prepare plans for experimental treatment of one or more of the Bell small watersheds and start supplementary pre-treatment observations.

7. Continue cooperation in-Service and with other agencies on watershed problems.

Activities and Accomplishments

Late in the year the organization of the division was changed by moving Kraebel into the position of research specialist, and making Colman Division Chief. Kraebel's duties will include extension of research findings, preparation of manuscripts on past research, cooperation with other Research divisions and National Forest Administration in the application of research results, and consultation with agencies involved in River Basin studies and foreign governments requiring the services of a specialist in watershed management.

The division has felt keenly the need to broaden its research objectives and scope. To this end Colman's seven-month study of influences research throughout the country has contributed a better understanding of problems and research needs common to the country as a whole, and of the kinds of research that may be most profitable in the California region. The division's efforts are now directed toward three objectives: (1) Publication of the results of all important research carried on by the division to date, (2) re-alignment of research plans to fill the gaps in past research, and (3) development of a research program covering the region, which will serve as the basis for future research planning.

San Dimas Experimental Forest

Activities on the San Dimas Experimental Forest, including the collection of records, compilation of data, and preparation of manuscripts, were continued with financial assistance from the State of California. Curtailment of funds resulted in the release of four employees late in the year.

The resignation of E. C. Stone, and later assignment of Henry Hellmers to the physiological studies of chaparral, resulted in some changes in this project. Field activities on the San Dimas Forest were handicapped by a serious accident to L. F. Reimann, which incapacitated him for several months.

Weather.--The winter season 1948-49 on the San Dimas Experimental Forest, and generally in southern California, was characterized by (1) a marked deficiency in precipitation for the second consecutive year--storms were small and of low intensity; (2) considerable snowfall extending even to the coast; and (3) very low temperatures.

Rainfall at Tanbark for 1948-49 amounted to 16.94 inches compared with 15.83 inches the previous year, and a 21-year average of 28.76 inches. Snow occurred over the entire Experimental Forest, reaching a depth of 4 feet in the high country. The minimum temperature at Tanbark Flat was 18 degrees in January, 2 degrees less than in the famous cold spell of January, 1937. The monthly mean temperature at Tanbark Flat was the lowest in 12 years, 12.7 degrees below the January average of 47.3 degrees.

Streamflow and Erosion.--Total streamflow yield and maximum flows from all watersheds within the San Dimas Experimental Forest were very low during the year owing to the 50 percent deficiency in annual rainfall for the second consecutive year and the lack of intense storms. Erosion from all watersheds was negligible. But Keril Canyon, below Big Dalton Dam and outside the experimental watersheds, continued to yield debris as the result of the 1947 fire.

As an example of hydrologic analyses that are being made, the following tables present yearly precipitation and streamflow for watersheds I and X within the Experimental Forest:

Watershed I (Wolfskill)--Area 1530 acres

Hydrologic year	Precipitation	Streamflow		
	Inches	Acre-feet	Inches	Percent of precipitation
1934-35	31.3	261	2.0	6.4
1935-36	23.1	211	1.6	6.9
1936-37	41.5	757	5.9	14.2
1937-38	44.8	1544	12.1	27.0
1938-39	20.2	495	3.9	19.3
1939-40	29.5	349	2.7	9.2
1940-41	49.4	1224	9.6	19.4
1941-42	17.4	403	3.2	18.4
1942-43	45.5	1479	11.6	25.5
1943-44	32.1	788	6.2	19.3
1944-45	33.5	776	6.1	18.2
1945-46	24.2	498	3.9	16.1
1946-47	28.3	471	3.7	13.1
1947-48	15.2	220	1.7	11.2
1948-49	18.8	198	1.6	8.5

Watershed X (Monroe)--Area 875 acres

Hydrologic year	Precipitation	Streamflow		
	Inches	Acre-feet	Inches	Percent of precipitation
1934-35	33.8	187	2.6	7.7
1935-36	25.8	111	1.5	5.8
1936-37	41.3	531	7.3	17.7
1937-38	41.1	Record incomplete		
1938-39	20.3	95	1.3	6.4
1939-40	27.4	73	1.0	3.6
1940-41	50.6	768	10.5	20.8
1941-42	17.5	64	0.9	5.1
1942-43	42.2	774	10.6	25.1
1943-44	31.3	333	4.6	14.7
1944-45	30.2	239	3.3	10.9
1945-46	25.9	170	2.3	8.9
1946-47	27.4	152	2.1	7.7
1947-48	15.2	12	0.2	1.3
1948-49	18.2	22	0.3	1.6

The variations in annual streamflow yield correspond generally with variations in rainfall. This relationship is not consistent, however, and shows the need for more detailed study of watershed hydrology. This need has been shown more conclusively by an analysis of Monroe Canyon which is included in the forthcoming publication by Rowe and Colman. In this analysis interception loss and evapo-transpiration were determined for the watershed in 1943-44 and 1944-45. Interception loss was calculated from the equation given above and evapo-transpiration was determined from analysis of 14 soil-moisture sampling plots on the watershed. For the two years the annual interception loss averaged 2.5 inches and evapo-transpiration (including an estimation of riparian water loss), 10.8 inches. Of nearly 18 inches of rainfall unaccounted for in the evapo-ative losses only about 4 inches appeared as streamflow. This suggests that more than 3 times as much water left the watershed as underground flow through the highly fractured rock than as streamflow. It appears that streamflow provides an incomplete measurement of the water yield of watersheds of this kind.

Lysimeter Studies.--Precipitation at the lysimeter area was only slightly greater than that of the previous year. Rainfall penetrated the large and unconfined lysimeters to an average depth of 54 inches in May, 1949, compared to depths of 30 to 36 inches in the spring of 1948. No supplementary water was added to the lysimeters this year. Soil-moisture samples were taken in each of the 26 large and 5 unconfined lysimeters in October, 1949. The results of this and comparable sampling in 1947 and 1948, and the condition of the vegetation growing in the lysimeters, are summarized here:

Vegetation	Average inches depth of water stored in soil						Vegetation condition 1/	
	Large lysimeters			Unconfined lysimeters			Large lysimeters	Unconfined lysimeters
	Oct. 1947	Oct. 1948	Oct. 1949	Oct. 1947	Oct. 1948	Oct. 1949		
California buckwheat	6.5	5.6	5.7	6.8	6.6	6.1	C	A
Chamise	6.7	6.6	6.1	8.7	5.7	5.8	C	A
Hoaryleaf ceanothus	6.6	6.0	5.8	11.7	6.5	6.0	D	A
California scrub oak	9.9	6.1	6.3	11.2	6.9	6.8	B	A
Coulter pine	7.7	7.3	6.8	8.4	7.4	7.3	B	A
None (surface kept bare)	15.0	14.2	15.8	-	-	-	-	-

1/ Condition in October 1949 is expressed thus:

A - Excellent; plants growing vigorously.
B - Good; plants thrifty but little growth.
C - Poor; plants alive but with excessive leaf fall.
D - Very poor; some plants dying.

These data indicate that: (a) The amount of water in the bare lysimeter each year greatly exceeded that in the other tanks; (b) the pine lysimeters contained more water in 1948 and 1949 than those in which the four chaparral species are growing; (c) differences in water storage between the buckwheat, chamise, ceanothus, and oak lysimeters were not significant in 1948 or 1949; (d) the unconfined lysimeters contained more water in 1948 and 1949 than the corresponding large lysimeters except those containing chamise. (The chamise unconfined lysimeters in 1947 contained about 2 inches more water than the tanks planted to this species.)

Soil-Moisture Instrument.--Soil-moisture units placed at $1\frac{1}{2}$, $4\frac{1}{2}$, $7\frac{1}{2}$, and $10\frac{1}{2}$-inch depths in triplicate in a plot at the San Dimas lysimeters were tested under field conditions. The units maintained the same soil moisture: electrical resistance relationship through four wetting and drying cycles. They did not, however, duplicate the laboratory calibrations previously determined for these units. As a result a new laboratory calibration procedure for fine-textured soils is being studied. The units are being calibrated in cores of undisturbed soil in order to learn whether this method will yield a calibration that will be the same in field and laboratory.

Patent on the soil-moisture instrument is still pending. The manufacturer has sold, to date, 1871 soil units and 32 meters. As a result of a recent paper by Colman and Hendrix, numerous requests for further information have been received, many of them from foreign countries. To date little information has been received from outside the Station relative to the performance of the instruments in the field.

Interception.--The bulletin "Rainfall interception by chaparral in California," by Hamilton and Rowe, presents an equation (IL = .062 P + .083) for the storm-by-storm estimation of interception loss. The equation was applied to the average Experimental Forest rainfall by individual storms to obtain an estimate of annual loss by interception.

Between 1934-35 and 1948-49 rainfall totaled 451.6 inches. Of this, 46.4 inches, or 10.3 percent, was calculated as interception loss. The maximum percentage loss, 13.0 percent, took place in 1948-49, a year of low rainfall. That year 2.3 inches of rain was lost from a rainfall of 17.7 inches. The minimum was 7.5 percent, and took place in the year of maximum rainfall; 3.8 inches was lost from 50.1 inches of rain. As was to be expected, percentage losses were higher than average in years of low rainfall and small storms, and conversely. With a range in annual rainfall from 15.2 to 50.1 inches, annual interception loss ranged from 1.9 to 4.3 inches.

Publications and Manuscript Preparation

Two Cooperative Bulletins Published.--Of the papers planned for publication this year two were published by the State of California under cooperative agreement between the Station and the State Division of Forestry: The one on trees and shrubs for erosion control by J. S. Horton and the one on rainfall interception by E. L. Hamilton and P. B. Rowe.

Peak Discharge.--The manuscript by Rowe, Countryman, and Storey, giving tables of peak discharge and erosion rates as influenced by fire, was reviewed in Washington early in the year. However, because of the cost of reproducing its 270 tables and because interest in it is confined to a limited number of technicians, the paper will not be published. The manuscript tables will be available to any who wish to consult them, and the method used in their development will be prepared as a Station release.

Rainfall Disposition.--The paper by P. B. Rowe and E. A. Colman has gone through review with the Experiment Station and is being made ready for Departmental review. Intended for publication as a U.S.D.A. Technical Bulletin, it gives the results of research conducted in two mountain areas: The San Gabriel Mountains and the Sierra Nevada.

The study reported in this manuscript had two phases. One phase employed small hillside runoff and soil-moisture sampling plots to determine water losses and water yield from natural tree and brush vegetation, and the effects of annual burning and of denudation upon the losses and yield. The other phase employed soil-moisture plots established in an 875-acre brush-covered watershed (Monroe Canyon) for which streamflow measurements were available, thus permitting interpretation of results on a watershed basis. Results of the second phase are summarized under Streamflow and Erosion in the San Dimas Experimental Forest section of this report.

Annual burning of the vegetation in both tree and brush types sampled did not appreciably affect total evapo-transpiration losses. It did reduce the infiltration capacity of the soil, thereby increasing surface runoff. The reduced interception loss in the brush type resulted in increased water yield (surface runoff plus seepage), but this increase was achieved at the expense of increased storm flows of surface runoff, and correspondingly reduced underground yields.

Denudation and maintenance of a vegetation-free soil eliminated all interception and transpiration losses. Total evaporation losses were reduced, but surface runoff was increased. During each summer the bare soils lost appreciable quantities of water from all depths, but drying was slower and less complete in deep than in shallow soils. Total water yield was greatest from plots with bare soil, but underground yield was greatest from the plots covered with natural vegetation.

Mustard Sowing.--Revision of the R-5 "Guide for mustard sowing ....." is not now contemplated in view of the revision of Research Note 37, reported last year.

Chamise-Chaparral Succession.--Writing was started by Horton and Kraebel on the manuscript describing development of vegetation after fire in the chamise-chaparral. This paper is based upon study of permanent sample plots established on fresh burns. The longest series of records was taken in the 1925 Barranca burn near Devil Canyon, northwest of San Bernardino. Other sample plots were established in the 1930 Waterman Canyon, 1931 Cholo Point, 1935 Frankish Canyon, and 1938 Fern Canyon burns. The succession story is similar on all burns studied, though species differed and the relative abundance of individuals varied with site and rainfall differences.

The species occurring on the plots can be classed as permanent and temporary. The permanent vegetation consists of species (notably Adenostoma fasciculatum) that have the ability of sprouting from the root crown after fire, and others (like Ceanothus crassifolius) that do not sprout, but develop from seed. The permanent vegetation regains dominance after fire by crowding out the temporary vegetation that enters during the first few post-fire years.

The temporary vegetation consists of (1) short-lived perennial herbs and subshrubs, and (2) annual herbs. Some of the perennial species (including Lotus scoparius and Eriophyllum confertiflorum) mature rapidly and may produce several generations of plants before being crowded out by the maturing chaparral shrubs. The annual herbs appear the first year after fire and increase in number and density for several years before disappearing. Some of them reappear in intershrub spaces in years of above-normal precipitation.

Germination of Chamise Seed.--Stone's paper on the relation of fire to germination of chamise seed was deferred because of his resignation. Four other papers reporting results of the physiological research were prepared:

"A rapid method of separating seed of chamise from the duff," by E. C. Stone and Jack Holt (submitted to Ecology).

"Water absorption from the atmosphere by plants growing in dry soil," by E. C. Stone, F. W. Went, and C. L. Young (submitted to Science).

"Hybrids of sugar pine by embryo culture," by E. C. Stone and J. W. Duffield (submitted to Journal of Forestry).

"Effect of fire on germination of chaparral seed: I, Rhus ovata," by E. C. Stone and G. Juhren (submitted to Journal of Botany).

"Interception by Pine" and "Storm Vector".--Analyses of additional data was required in the preparation of manuscripts on "The storm vector," by E. L. Hamilton, and "Rainfall interception by second-growth ponderosa pine in California," by P. B. Rowe and T. M. Hendrix. A preliminary outline was prepared for the storm-vector manuscript and a detailed outline for the interception paper.

Rainfall Measurement

Studies relating to the accuracy of rainfall records have indicated that records from standard rain gages on the San Dimas require correction, particularly during large and violent storms. It is therefore important to devise a method to effect this correction.

Earlier studies had shown that tilted rain gages provided accurate records of rainfall. Wind velocity and direction, and angle of inclination of the rain, were found to be related to the differences in catch between vertical and tilted gages. The percent difference between vertical and tilted gages was found to be related to the angle of inclination of rainfall. Angle of inclination was related to storm wind velocity. As continuous records of wind velocity and direction were available from several of the climatic stations on the Experimental Forest, a means was at hand to determine which rainfall records needed correcting, and to supply data necessary to effect this correction.

An equation developed by Fourcade[1/] was used for the conversion of vertical gage measurements to the catch in a tilted gage. An example of the usefulness of the equation is presented here. A tilted and a vertical gage located at 5100 feet elevation in the head of Fern Canyon were chosen for this purpose. They are situated close to a vectopluviometer in Fern Multiple Watershed No. 1. For each of 43 storms the catch of the vertical gage was corrected by the Fourcade equation.

The observed tilted gage total was 53.13 inches, or 8.6 percent greater than the adjacent vertical gage catch of 48.92 inches. The corrected vertical gage catch (53.95 inches) is within 1.6 percent of the observed tilted gage catch.

The same method of correction has been used on other paired vertical and tilted gages on the San Dimas and has given similarly good results. It offers for the first time a means of improving the accuracy of past rainfall measurements that were made with vertical gages. Sufficient data regarding wind direction and velocity in storms are available to permit correction of past rainfall records throughout the Experimental Forest, and thus to establish, storm-by-storm the correct rainfall reaching each watershed.

Two results will come from the foregoing analysis: A paper ("The storm vector") describing the correction procedure, and thus establishing a method for utilizing vertical rain gage records in mountainous country; and a reduction in the number of rain gages on the Experimental Forest.

1/ $\frac{(r - v)}{v} = \tan\alpha \tan i \cos \theta$

Where v = rain measurement by the conventional vertical gage;
r = rain measurement by a tilted gage;
α = degree of slope of the ground surface;
i = angle of inclination of rainfall;
θ = angle between the direction of the rain and the aspect of the slope.

The elements i and θ alone must be measured specially, and can be determined from wind velocity and direction records, or by means of a vectopluviometer.

("Some notes on the effects of the incidence of rain on the distribution of rainfall over the surface of unlevel ground," by H. G. Fourcade. Roy. Soc. So. Africa. Trans. Vol. XXIX, Part III, 1942.)

Plant Physiology

The physiological studies of chaparral are being conducted as a cooperative project with the Angeles Forest Flood Control Project and the California Institute of Technology.

Seven chaparral species were grown in sand cultures for study of macro-mineral nutrient deficiency. The plants were harvested and measured. The data are undergoing statistical analysis, and the plant material has been transferred to the Forest Service Soils Laboratory at Arcadia for ash analyses. In extension of the nutrition studies to local mountain soils, seeds, soil, and equipment have been obtained and prepared for greenhouse tests. Soils developed on Wilson Diorite, Lowe Granodiorite, and white Anorthosite are being used. These soils were previously tested for nutrient deficiencies (using standard lettuce and barley) by Dr. Vlamis of the University of California. He found all to be deficient in nitrogen and phosphorus. The present study will determine whether these deficiencies are important in the growth of native chaparral plants.

Watershed Treatment

Plans for experimental treatment of the Bell Canyon small watersheds were held in abeyance, pending preparation of new research plans for the entire San Dimas Experimental Forest.

In-Service and Other Cooperation

Soil Stabilization in Burned Watersheds.--Mustard- and grass-sown areas in the Wheeler Springs and Green River burns of 1948 were examined. The mustard grew with good density in more than 70 percent of the area designated for sowing. The grasses, even though benefited by rain in mid-May, produced generally sparse stands. Annual rye grass (Lolium multiflorum) grew well enough to warrant further testing as to its suitability for erosion-control sowing on burned areas. The growing season was characterized by light but well-spaced rainfall, extremely low temperatures, and winds of gale force. There was practically no water erosion in either burn, but wind erosion was severe. A full report will be prepared for Station release.

Air photographs of the Green River burn were obtained and ground controls were established for the purpose of estimating the quantity of debris eroded by wind from the burned area in the winter of 1948-49, and for comparison of erosion conditions in adjacent burned and unburned areas. The pictures were made by the First Marine Aircraft Wing, El Toro Marine Base, by arrangement with the Supervisor, Cleveland National Forest. The photo interpretation and computations are yet to be made.

Other Activities.--For the last 3 months of 1949, Gleason was detailed to Range Research on the new brushland improvement project, to assist with watershed management aspects of the study, as reported under Range Research.

Rowe, in company with members of the Forest Survey Division and the University of California, took part in field trips in the San Francisco Bay region and Madera County, to study the soils information being collected for the Forest Survey. He prepared for the use of the Forest Survey Division a tabulation of the soil characteristics that should be considered in appraising the hydrologic features of soils.

Recommendations were made to the Angeles Forest Flood Control Project relative to the collection of hydrologic records. Streamgaging instruments were loaned to the Project for use in Coon Canyon, and suggestions were made for the improvement of the raingage network there.

At the request of the Board of Agriculture and Forestry, Territory of Hawaii, recommendations were made regarding the installation and conduct of watershed studies.

Forest Service experience in the use of aircraft for sowing mustard seed in mountainous areas was described by Gleason at the Statewide Conference on Agricultural Usage of Aircraft, held on the University of California campus at Davis, in February. The record showed that of the 128,000 acres sown since the start of the work in 1932, about two-thirds were covered by airplanes and helicopters.

In September Gleason acted as instructor of watershed management in a teachers' workshop of the Plumas County Public Schools. The workshop was the first one in California at which conservation of natural resources had been made the theme of an institute attended by all grammar and high school teachers.

In March Kraebel participated with the Regional Engineer and members of the Station Flood Control Survey group in a field examination and discussion of a tentative program of upstream improvement and channel stabilization for the San Antonio Canyon tributary of the San Gabriel River. The problem here is one not only of stabilizing great quantities of rock debris already in transit but also of slowing down the rate of generation of such material in the future. The program calls for some heavy structural work as a first step, and the placement and design of these will require ingenuity and skill of high order. Neither natural nor artificial revegetation can effect the type of control needed in this rugged canyon.

In June Kraebel took part, with Washington, Regional, and Forest officials, in a field and office conference on the Angeles Forest Flood Control Project. Purpose was to consider the status and future conduct of the program with special attention to maintaining proper balance between the forestry and engineering measures.

Pursuant to a request from the Eastern Rockies Forest Conservation Board for a consultant in forest influences, Kraebel spent three weeks studying watershed management problems in Alberta. His impressions and recommendations have been presented in a report to the Board.

Two field seminars dealing with the general subject of minimizing watershed damages by logging in the Sierra Nevada were participated in by Kraebel. The first was part of a "short course" for technicians of the State Division of Forestry. The second was a meeting of forest supervisors and timber-sale officers from several national forests at the Stanislaus Experimental Forest to observe and discuss the efforts being made to prevent and correct erosion damage in the experimental logging area.

Plans for 1950

1. Continue planning the development of research programs in the California region.

2. Continue operation of the San Dimas Experimental Forest and analysis of data from the area.

3. Carry through technical review stages the following publications:

"Disposition of rainfall in two mountain areas in California," by P. B. Rowe and E. A. Colman. (For departmental publication.)

"Development of vegetation after fire in the chamise-chaparral of southern California," by J. S. Horton and C. J. Kraebel.

4. Draft manuscripts on:

Hydrologic analysis used to determine the effects of fire on peak discharge and erosion rates of southern California watersheds, by P. B. Rowe, C. M. Countryman, and H. C. Storey. (For Station release.)

Rainfall interception by second-growth ponderosa pine, by P. B. Rowe and T. M. Hendrix. (For Journal of Forestry.)

Structure of the southern California chaparral, by J. S. Horton.

First year's results of mustard and grass sowing in the Wheeler Springs and Green River burns, by C. H. Gleason and D. R. Cornelius. (For Station release.)

5. Plan a progress report on the San Dimas Experimental Forest, this report to include analysis of rainfall, streamflow, and erosion data.

6. Develop a plan for the treatment phase of research on the San Dimas Experimental Forest.

7. Complete analysis of rainfall studies on the San Dimas Experimental Forest, and correct early rainfall records.

8. Continue physiological and ecological studies in cooperation with the Angeles Forest Flood Control Project and the California Institute of Technology.

9. Continue studies of erosion and plant development on burned areas in southern California.

10. Collaborate with the Range Research Division in examining and reporting results of the brushland improvement study.

11. Continue cooperation in-Service and with other agencies on watershed management problems.

FLOOD CONTROL SURVEYS
(D. M. Ilch, Chief of Division)

Objectives for 1949

1. Preliminary Examination

a. Complete examination and report on the Eel--Mad Rivers in California.

b. Complete examination and report on the Klamath River in California and Oregon.

c. Assist the Soil Conservation Service in preliminary examinations of the San Francisco Bay watersheds and the central California coast watersheds.

2. Advance Studies

a. Complete survey work outlines for Sacramento--San Joaquin group of streams.

b. Complete survey work outline for Columbia River watershed.

c. Continue maintenance of data and reference files on watersheds scheduled for investigation and survey.

d. Assist in the preparation of survey work outlines for watersheds to be investigated under Soil Conservation Service direction.

3. Surveys

a. Complete field processing of reports on Santa Ana, San Gabriel, Santa Maria, Santa Clara, Ventura, and San Diego group of streams by discussing programs with local interests and submitting reports for review by the regional offices of the Federal Inter-Agency River Basin Committee members.

b. Continue survey of Willamette River watershed, complete initial investigations and begin program development stage.

c. Begin new survey of either Columbia River watersheds or Sacramento and San Joaquin streams, depending upon availability of funds for fiscal year 1950.

d. Assist Soil Conservation Service in surveys of Russian River in California and other watersheds as requested.

Activities and Accomplishments

The objectives for 1949 were not met in full due to circumstances beyond field control. The five surveys scheduled for completion in 1949 had to be held over awaiting certain decisions in the Department regarding participation of other agencies and policies affecting evaluation of

programs. In addition, plans to start a survey of the Sacramento--San Joaquin River watersheds were deferred indefinitely when the Department announced the basin-wide survey of the Columbia River, in which this Station will participate. In furtherance of this major job, the Flood Control Survey Division diverted almost all of its effort to pushing the Willamette River survey nearer to completion. Consequently, the accomplishments on the following projects fall short of the goals set last year.

Preliminary Examinations

Eel--Mad Rivers.--Field examination of these two watersheds was completed during the year. A preliminary examination report was prepared and approved by the Regional Office of the Forest Service and the Soil Conservation Service prior to transmittal to Washington. The report recommended a survey to investigate and develop a runoff and waterflow retardation and soil erosion prevention program.

Klamath River.--Field reconnaissance of the Klamath watershed was completed in 1949 with the assistance of the Soil Conservation Service. A rough draft examination report was prepared for local review by the Soil Conservation Service and the Forest Service. This report also will recommend a survey of the watershed.

San Francisco Bay and Central California Coast Watersheds.--Although the Soil Conservation Service scheduled these watersheds for preliminary examination in 1949, this Division was not called upon to assist in either field examinations or report preparation. Therefore, it is assumed that preliminary examination reports on these watersheds have been deferred.

Advance Studies

An investigation was made of the 7,000-acre burn on the watershed of Lytle Creek in the Santa Ana River drainage to determine the need for emergency flood protection. The emergency report recommended sowing some 1,500 acres with mustard seed to establish a plant cover quickly. This work was accomplished in cooperation with San Bernardino County and the San Bernardino National Forest at a cost of about $2,400. No emergency flood-control funds were requested for this work.

Four temporary plots were established on the Stanislaus National Forest to measure erosion and sediment from logging skid trails. Each plot consisted of a log and earth-fill catchment basin constructed at the break-in slope on each of four skid trails used during the 1949 logging season. Cross-sections and profiles were recorded for follow-up measurement.

Sedimentation records of selected southern California reservoirs were maintained during the year. All field work was accomplished by other Federal or local agencies, and arrangements were made for obtaining the survey records. These reservoirs included the Gibraltar, Juncal, and several smaller ones in San Diego County.

Surveys

Wrightwood on Sheep Creek, tributary to the Mojave River.--A fourth revision of this report was made in accordance with instructions from the Washington Office. The report originally recommended a complete plan of protection and an alternate plan of limited protection. The last revision deleted the alternate plan and provided for public acquisition in lieu of zoning the undeveloped but potentially damageable areas. The latest revision of this report is now being reviewed by the Secretary's Office.

San Gabriel River (California) Survey Report.--This survey report is now undergoing revision to meet the requirements of the Secretary's memorandum of September 29, 1949, "Policies and Procedures to Guide the Preparation of Flood Control Survey Reports." Earlier in the year a meeting was held with local representatives to discuss the type of program under consideration, its objectives, and estimated physical benefits. The original report was reviewed by the State Review Committee consisting of representatives of the State Engineer's Office and the College of Agriculture.

Santa Ana River (California) Survey Report.--Revision of this survey report is also under way. Changes similar to those required in the San Gabriel report will also be necessary in the Santa Ana in order to make it conform to current policies of the Secretary. During the year local representatives had an opportunity to review the over-all program. The State Review Committee also reviewed the report.

Santa Maria River (California) Survey Report.--Discussion of the over-all program with local interests early in the year was accomplished. Certain changes in the program were made following this discussion in order to give consideration to additional local damage areas. The revision necessary to meet the requirements of the Secretary's new instructions will be more extensive than required for either the San Gabriel or the Santa Ana reports. Among the items needing reconsideration are (1) the impact of the Bureau of Reclamation and Corps of Engineers revised plans for flood-control and water conservation; (2) re-examination of sedimentation estimates; (3) drastic land-use changes in the Cuyama Valley, from agriculture to oil developments and the effect on land management.

Santa Clara--Ventura Rivers (California) Survey Report.--This report is undergoing revision in compliance with recent instructions from the Secretary of Agriculture. The over-all program, its objectives and estimated physical benefits have been discussed with local interests and the State Review Committee.

San Diego County (California) Group of Streams.--The tentative program for these watersheds was considered in the field by the State Review Committee earlier in the year. Under present instructions, extensive revision of this report will be necessary to bring it up to standard. Lack of recent flood records and flood damages has increased the problem involved in justifying the type of program considered

necessary for this area. Lack of interest in flood control on the part of the local people and agencies has added to the task of program development. As is to be expected in any area of deficient water supply, water conservation is the keynote rather than flood control.

Columbia River Survey.--As of October 1949, the Division's survey work on the Willamette River watershed became a segment of the basin-wide survey of the Department. We became one member of a five-party team consisting of the survey groups of the Soil Conservation Service and the Pacific Northwest, Northern Rocky Mountain, Intermountain, and California Forest and Range Experiment Stations. Under the present team arrangement, the California Station assumes responsibility for survey of the Willamette, Rogue, Umpqua, Lewis, and Cowlitz Rivers. All work thus far has been concentrated on the Willamette watershed. Supplemental damage surveys have been made on 33 tributaries not protected by works of the Corps of Engineers. Analysis of flood causes and flood sources has been in progress through the year with special emphasis on the evaluation of land uses on stream discharges. Storm frequencies for selected tributaries were developed for use in the damage appraisals. Work outlines and plans were completed for detailed examination of a number of tributary streams to determine the feasibility of upstream structural measures.

Collection of data and maps has been started prior to field work on the Rogue and Umpqua Rivers this summer.

Salinas River (California) Survey.--A limited amount of assistance was given to the Soil Conservation Service in the preparation of this survey report.

Russian River (California) Survey.--This survey, under the direction of the Soil Conservation Service, required the assistance of the Division in the development of the wild land portion of the remedial program.

Miscellaneous

The Division participated in a number of subcommittee meetings of both the Columbia Basin Inter-Agency Committee and the Pacific Southwest Technical Committee on Sedimentation.

Numerous conferences with State and local interests regarding review of survey reports resulted in the reconsideration by the State of current procedures of review. Subsequently, the State proposed a revised procedure consistent with requirements of the 1944 Flood Control Act; the revision has been concurred in by the Secretary. This procedure channels all survey reports through the State Director of Public Works rather than the College of Agriculture.

Plans for 1950

1. Preliminary Examination

   a. Complete report on Klamath River.

b. Assist Soil Conservation Service in any preliminary examinations that may be scheduled for 1950.

2. Advance Studies

a. Continue maintenance of data and reference files on watersheds scheduled for future investigation and survey.

b. Complete survey work plans for Rogue, Umpqua, Lewis, Cowlitz Rivers in Oregon and Washington.

c. Complete plans for installing additional plots to measure and observe effects of logging operations on streamflow and erosion.

d. Continue participation in Pacific Southwest Inter-Agency Technical Committee activities in the Colorado River area.

3. Surveys

a. Complete revision and field processing of survey reports on San Gabriel, Santa Ana, Santa Maria, Santa Clara--Ventura, and San Diego group of streams.

b. Complete survey of Willamette River watershed.

c. Continue participation in Columbia River Basin Comprehensive Survey.

d. Begin investigations of Rogue, Umpqua, Lewis, and Cowlitz watersheds.

e. Assist Soil Conservation Service in completing Russian and Salinas River surveys.

STAFF PUBLICATIONS, 1949

Printed

Amidon, R. E.
Discussion of Cadastral surveys and resurveys. Amer. Soc. Civ. Engin. Proc. 75(4): 551-552. April 1949.

Amidon, R. E.
Discussion of Multiple-purpose reservoirs: a symposium. Amer. Soc. Civ. Engin. Proc. 75(6): 881-883. June 1949.

Anderson, Henry W.
Does burning increase surface runoff? Jour. Forestry 47(1): 54-57. January 1949.

Anderson, H. W., and H. K. Trobitz
Influence of some watershed variables on a major flood. Jour. Forestry 47(5): 347-356. May 1949.

Anderson, Henry W.
Flood frequencies and sedimentation from forest watersheds. Amer. Geophys. Union. Trans. 30(4): 567-584. August 1949.

Anderson, H. W.
Discussion of Trends in runoff in the Pacific northwest, by C. C. McDonald and W. B. Langbein. Amer. Geophys. Union. Trans. 29(3): 387-397. 1948. Amer. Geophys. Union Trans. 30(4): 603-604. 1949.

Bentley, J. R. (See Hormay, A. L.)

Bentley, J. R.
Use of California annual-plant forage by range rodents. By Henry S. Fitch and J. R. Bentley. Ecology 30(3): 306-321. July 1949.

Colman, E. A., and T. M. Hendrix
The fiberglas electrical soil-moisture instrument. Soil Science 67(6): 425-438. June 1949.

Cumming, W. C. (See Duffield, John W.)

Duffield, John W., and W. C. Cumming
Does Pinus ponderosa occur in Baja California? Madroño 10(1): 22-24. January 1949.

Duffield, J. W., and Palmer Stockwell
Pine breeding in the United States. U. S. Department of Agriculture. Yearbook of Agriculture 1949. 147-153. 1949.

Duffield, John W.
The pines of the Eddy Arboretum. Arboretum Bul. 12(4): 17-20. Winter, 1949.

Duffield, J. W., and A. R. Liddicoet
Variability of rooting in a small second-generation population of the hybrid Pinus attenuradiata. Jour. Forestry 47(2): 107-109. February 1949.

Dunning, Duncan
A sugar pine regeneration cutting experiment. Contribution to: West Coast Lumberman 76(3): 62, 64. March 1949.

Dunning, Duncan
Pine forests of California. By B. O. Hughes and Duncan Dunning. U. S. Department of Agriculture. Yearbook of Agriculture 1949. 352-358. 1949.

Fowells, H. A.
Cork oak planting tests in California. Jour. Forestry 47(5): 357-365. May 1949.

Gleason, Clark H., and Donald G. MacBean
Use of the helicopter for sowing mustard seed in burned areas of southern California. Jour. Forestry 47(3): 192-195. March 1949.

Hamilton, E. L.
The problem of sampling rainfall in mountainous areas. (In Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability. p. 469-474. Berkeley, 1949. University of California Press.)

Hamilton, E. L., and P. B. Rowe
Rainfall interception by chaparral in California. Sacramento, Calif. 43 p. (U. S. Department of Agriculture. Forest Service. In cooperation with California Department of Natural Resources, Division of Forestry) 1949.

Hamilton, E. L.
Stem surface area determination (by) nomograph. Jour. Forestry 47(1): 57. January 1949.

Hasel, A. A.
Long-term silvicultural experiment on methods of cutting. (In Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability. p. 477-479. Berkeley, 1949. University of California Press.)

Hasel, A. A., and Adon Poli
A new approach to forest ownership surveys. Land Economics 25(1): 1-10. February 1949.

Hendrix, T. M. (See Colman, E. A.)

Hormay, A. L.
Getting better records of vegetation changes with the line interception method. Jour. Range Management 2(2): 67-69. April 1949.

Hormay, A. L., and J. R. Bentley
The land-variability factor in cattle-grazing experiments. (In Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability. p. 465-467. Berkeley, 1949. University of California Press.)

Horton, Jerome S.
Trees and shrubs for erosion control in southern California mountains. 72 p. (U. S. Department of Agriculture. Forest Service. In cooperation with California Department of Natural Resources, Division of Forestry) 1949.

Jensen, Herbert A., and Robert N. Colwell
Panchromatic versus infrared minus-blue aerial photography for forestry purposes in California. Photogrammetric Engin. 15(2): 201-223. June 1949.

Liddicoet, A. R. (See Duffield, J. W.)

May, Richard H. (See Vaux, Henry J.)

Mirov, N. T.
Contribution to Woody-plant seed manual. U. S. Department of Agriculture Misc. Pub. No. 654. 416 p. June 1948.

Mirov, N. T., T. H. Wang, and A. J. Haagen-Smit
Chemical composition of gum turpentines of pines: a report on Pinus strobus, P. cembra, P. taeda, P. radiata, and P. virginiana. Jour. Amer. Pharm. Assoc., Scientific Edition 38(7): 403-407. July 1949.

Mirov, N. T., and A. J. Haagen-Smit
Composition of gum turpentine of knobcone pine. Jour. Forestry 47(9): 721-722. September 1949.

Mirov, N. T., A. J. Haagen-Smit, and James Thurlow
Composition of gum turpentine of Pinus lambertiana. Jour. Amer. Pharm. Assoc., Scientific Edition 38(7): 407-408. July 1949.

Mirov, N. T.
A tree is a living thing. U. S. Department of Agriculture. Yearbook of Agriculture 1949. 1-10. 1949.

°Poli, Adon (See Hasel, A. A.)

°Economist, Bureau of Agricultural Economics, cooperating in Forest Survey land ownership studies.

Righter, F. I.
The Chase oak, a new giant hybrid oak from Santa Clara County, California. By H. E. McMinn, E. B. Babcock, and F. I. Righter. Madroño 10(2): 51-55. April 1949.

Righter, F. I., and Palmer Stockwell
The fertile species hybrid, Pinus murraybanksiana. Madroño 10(3): 65-69. July 1949.

Rowe, P. B. (See Hamilton, E. L.)

Stockwell, Palmer (See Righter, F. I.)

Stockwell, Palmer (See Duffield, J. W.)

Trobitz, H. K. (See Anderson, H. W.)

Vaux, Henry J., and Richard H. May
A regional study of lumber use in housing. Jour. Forestry 47(4): 260-264. April 1949.

Wieslander, A. E.
Rating soils for timber sites. By R. Earl Storie and A. E. Wieslander. Soil Sci. Soc. Amer. Proc. 13: 499-509. 1948.

Wyckoff, Stephen N.
The work of the California Forest and Range Experiment Station. (In Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability. p. 459-463. Berkeley, 1949. University of California Press.)

Processed

Burks, George F.
Estimated lumber production in California - 1948. 6 p. Research Note No. 65. December 8, 1949.

Clements, V. A., C. W. Stevens, and D. F. Roy
Form-class volume tables for ponderosa pine, Douglas-fir, and white fir in California. 125 p. Research Note No. 60. April 1949.

Clements, V. A., C. W. Stevens, and D. F. Roy
Form-class volume tables for sugar pine and red fir in California. 137 p. Research Note No. 61. June 1949.

Dunning, Duncan
Roots of forest trees. 42 p. Research Note No. 52. Reissued 1949.

Fowells, H. A.
An index of ripeness for sugar pine seed. 5 p. Research Note No. 64. November 1949.

Gleason, Clark H.
Forest Service use of aircraft for sowing burned-over watershed land in southern California. Minutes of State-wide conference (forum) on agricultural usage of aircraft. Davis, Calif. February 8-9, 1949. p. 27-33.

Kimbrough, Emery F.
Making paper tubes for plant propagation. 5 p. Research Note No. 59. January 1949.

May, Richard H., and Alexander Simontacchi
Production of logs and bolts for plywood, veneer, pulpwood, and cooperage in California, 1948. 5 p. Research Note No. 63. September 15, 1949.

Roy, D. F. (See Clements, V. A.)

Roy, D. F. (See Clements, V. A.)

Simontacchi, Alexander (See May, Richard H.)

Smith, Harvey H.
Seasoning California black oak. 8 p. Research Note No. 62. July 1949.

Stevens, C. W. (See Clements, V. A.)

Stevens, C. W. (See Clements, V. A.)

Wieslander, A. E.
The statewide forest survey. Progress report on the redwood region survey. Redwood Region Logging Conference. Proc. 11th Annual meeting and equipment show. Eureka, California, May 27-28, 1949. p. 5-8. Mimeographed.